UNCLASSIFIED

STUDY OF PHYSICAL AND CHEMICAL CHARACTERISTICS OF BALLOONS AND BALLOON MATERIALS

REPORT NO. 6

Signal Corps Contract No.
DA-36-039-SC-84925

Department of the Army Project No.
3D36-21-001-04

SIXTH QUARTERLY PROGRESS REPORT

25 July 1961 - 24 October 1961

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Signal Corps Contract No.:	DA-36-039-SC-84925
SC Technical Requirements No.:	SCL-5205A, 26 Aug 1959
Department of the Army Project No.:	3D36-21-001-04

SIXTH QUARTERLY PROGRESS REPORT

Period covered by this report:
25 July 1961 - 24 October 1961

The object of this study is to further the investigation of the physical and chemical characteristics of balloons and balloon materials originated in Signal Corps Contract DA-36-039-SC-72386 and continued in Signal Corps Contract DA-36-039-SC-78239.

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PURPOSE

The aims of this study are to improve the performance of meteorological balloons by improvements in the basic formulations, by revised or new methods of pretreatment or preconditioning, and by modification of the aerodynamic shape of such balloons.

This work will be performed according to the following schedule:

TASK A: STUDY OF BALLOON FILMS AND THEIR EFFECT ON BALLOON FLIGHT PERFORMANCE

- Phase 1: Study of the Literature
- Phase 2: Study of Raw Materials
- Phase 3: Development of Formulations with Desirable Film Properties
- Phase 4: Correlation of Film Properties with Flight Data

TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON FILM PERFORMANCE

- Phase 1: Effect of Pre-elongation
- Phase 2: Effect of Ozone
- Phase 3: Effect of Infra-Red Radiation
- Phase 4: Effect of Ultra-Violet and Other Short-Wave Radiation
- Phase 5: Correlation of Physical Properties with Flight Performance
- Phase 6: Prediction of Balloon Performance

TASK C: STUDY OF BALLOON CONFIGURATION

- Phase 1: Design and Construction of Equipment
- Phase 2: Construction of One-Piece Balloons for Flight Testing
- Phase 3: Construction of Balloons having Mechanical Attachments to Improve Rate of Ascent
- Phase 4: Construction of Balloons having Selective Compound Modulation

TASK D: FIELD EQUIPMENT FOR PRECONDITIONING BALLOONS

ABSTRACT

The following is a resume of the work performed during the period from July 25, 1961, through October 24, 1961.

TASK A: STUDY OF BALLOON FILMS AND THEIR EFFECT ON BALLOON FLIGHT PERFORMANCE

Phase 1: Study of the Literature

A continued study of the literature revealed nothing of interest during this period.

Phase 2: Study of Raw Materials

Part A: Neoprene Polymers

The investigation of three new types of neoprene latex has been started.

A study of the effect of aging neoprene latex before compounding and of aging the compounded latex before dipping was conducted. Physical properties were determined in an effort to determine whether more uniform results could be obtained by such a maturing process.

Part B: Plasticizers

No progress during this period.

Part C: Antioxidants and Antiozonants

No progress during this period.

Part D: Accelerators

An investigation was made of the effect of varying the amount of Merac and Accelerator 833 in a balloon compound. Amounts of accelerator ranging from 0.5 parts to 3.0 parts were employed, and the physical properties of the compounds were measured at room temperature and at -40°C.

It was shown that increasing the amount of Merac had little effect at room temperature but that elongation at -40°C increased. Increasing the amount of Accelerator 833 increased elongation and reduced modulus at both room temperature and at -40°C.

Part E: Polymers other than Neoprene

No progress during this period.

ABSTRACT (continued)

TASK A, Phase 2 (continued)

Part F: Reinforcing Fillers

The effect of Mistron Vapor in a balloon compound was determined. It was shown that this material could be used to increase the modulus and tensile strength at room temperature without substantially reducing the elongation. At -40°C, Mistron Vapor has little effect on any of the physical properties except the 200% modulus which is slightly increased.

The possibilities were investigated of using zinc resinate instead of zinc oxide by dissolving it in the plasticizer and then making an emulsion instead of a dispersion of zinc oxide.

Phase 3: Development of Formulations with Desirable Film Properties

Part A: High-Altitude Balloon Compounds

No progress during this period.

Part B: Dual-Purpose Balloon Compounds

Compounds were designed to contain Merac instead of Accelerator 833, and to contain a combination of Merac and Accelerator 833. Physical properties were measured and shown to be satisfactory at room temperature, at -40°C, and at -70°C.

Two compounds were prepared in which Dibutyl Sebacate is the only plasticizer and in which Neoprene 400 and Neoprene 571 were used respectively to increase the modulus. The compound containing Neoprene 400 had satisfactory physical properties, but the gel was too soft to handle. The compound containing Neoprene 571 had satisfactory physical properties at room temperature but froze at -70°C. This gel was also very soft though less so than the one containing Neoprene 400.

A dual-purpose compound containing Mistron Vapor was shown to have good physical properties at room temperature and at -70°C.

Part C: Fast-Rise Balloon Compounds

A fast-rise, day-flight compound was designed in which Mistron Vapor was used to provide a high modulus. This compound had a very high modulus and good elongation at both room temperature and at -40°C. After post-plasticizing the physical properties looked promising for use in fast-rise, night-flight balloons.

ABSTRACT (continued)

TASK A (continued)

Phase 4: Correlation of Film Properties with Flight Data

Part A: High-Altitude Balloons

No progress during this period.

Part B: Dual-Purpose Balloons

Flights were conducted with balloons made from compound A3-106. Variations in cure and wall thickness were incorporated, and one group was subjected to accelerated heat aging before flight.

Balloons were also made from compounds containing Merac (A3-132 and A3-136) and a combination of Merac and Accelerator 833 (A3-135), and flight tests were conducted. Additional balloons made from compound A3-129 which contains Butoxy Ethyl Oleate were also flown. All of the above flights were satisfactory.

Despite the softness of the gel, balloons were made from compound A3-133 which contains Dibutyl Sebacate as the only plasticizer and Neoprene 571. Flights were conducted which were generally less satisfactory than those obtained with balloons made from the other compounds.

Balloons were also made from a compound containing Mistron Vapor (A3-137). These balloons performed satisfactorily and had rates of ascent slightly above average for this type of balloon.

Part C: Fast-Rise Balloons

No progress during this period.

TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON FILM PERFORMANCE

Phase 1: Effect of Pre-elongation

No progress during this period.

Phase 2: Effect of Ozone

No progress during this period.

Phase 3: Effect of Infra-Red Radiation

Measurements were made of the spectral characteristics of neoprene films cut from white, red, and black balloons and expanded to varying degrees in order to provide films of different thicknesses. Transmittance, reflectance, and absorptivity were determined.

ABSTRACT (continued)

TASK B (continued)

Phase 4: Effect of Ultra-Violet and Other Short-Wave Radiation

The investigation of the effect of ultra-violet light from a 2800 A° bulb was started. Initial tests showed no action even in air, and additional bulbs have been obtained in order to increase the concentration of the radiation.

Phase 5: Correlation of Physical Properties with Flight Performance

No progress during this period.

Phase 6: Prediction of Balloon Performance

Part A: Determination of Burst Altitude from Residual Elongation

No progress during this period.

Part B: Determination of Dimensions of Fast-Rising Balloons

A theoretical study was conducted on the dimensions necessary for two-piece, fast-rising balloons designed to reach altitudes of 75,000 feet and 100,000 feet. Using the performance of standard production balloons as a basis, it was shown that this method of calculation predicted the dimensions of the ML-541 and ML-550 balloons quite clearly.

Part C: Determination of Physical Properties of Constant-Level Balloon Films

A theoretical determination was made of the modulus tension developed in a balloon designed to float at a fixed altitude.

Part D: Analysis of Stress in Sounding Balloons

A theoretical study was made of the stress developing in a sounding balloon during flight. Since the balloon will rupture at the point of maximum stress, it is conceivably possible to improve flights by reinforcing these areas. Equipment was designed which photographs a balloon at the moment of burst in order to confirm the theoretical predictions of this study.

TASK C: STUDY OF BALLOON CONFIGURATION

Phase 1: Design and Construction of Equipment

No progress during this period.

ABSTRACT (continued)

TASK C (continued)

Phase 2: Construction of One-Piece Balloons for Flight Testing

No progress during this period.

Phase 3: Construction of Balloons having Mechanical Attachments to Improve Rate of Ascent

Two-piece, streamlined balloons were manufactured from a compound containing Mistron Vapor (A3-134). These and similar balloons made from compound A3-102 were flown in the daytime and some of the A3-134 balloons were post-plasticized and flown at night.

The altitudes reached were quite good in almost every flight, and the rate of ascent of the day-flight balloons was fairly satisfactory. The rate of ascent of the night-flight balloons was less than is desired. An evaluation of the flights in detail indicated that the modulus of these compounds, particularly of A3-134, is higher than is desirable.

Phase 4: Construction of Balloons having Selective Compound Modulation

No progress during this period.

TASK D: FIELD EQUIPMENT FOR PRECONDITIONING BALLOONS

No progress during this period.

PUBLICATIONS, LECTURES, REPORTS, AND CONFERENCES

No publications, lectures, or reports resulted from this study during the period covered by this report.

No conferences were held on this subject during this period.

FACTUAL DATA

TASK A: STUDY OF BALLOON FILMS AND THEIR EFFECT ON BALLOON FLIGHT PERFORMANCE

Phase 1: Study of the Literature

A continued study of current literature during the past quarter has not revealed anything of interest.

Phase 2: Study of Raw Materials

Part A: Neoprene Polymers

Samples of neoprene polymers which were not evaluated previously have been received from Du Pont. These are identified as Neoprene 572, Neoprene 673, and Neoprene 450. Neoprenes 572 and 673 are types which were, at one time, offered for sale but were withdrawn because of lack of interest. Neoprene 450 is the latest addition to the regular line of neoprene latices. Work on these samples has been started but there is, as yet, nothing to report.

It has been observed that the physical properties of production compounds show substantial variations over a period of several months. This was not always associated with change in the neoprene latex lot numbers, and it appeared that the age of the latex was at least partially responsible for this variation. A program was therefore initiated to determine the effect of aging of neoprene latex before compounding and the effect of aging the compound itself.

Compound A3-105 was selected, and a drum of Neoprene 750 and one of Neoprene 571 were supplied immediately after manufacture by Du Pont. A batch of compound A3-105 was prepared as soon as the latex was received, and plates were dipped and cured immediately according to standard procedure.

After four weeks a further batch of compound was prepared, and plates were dipped from this and from the original compound which had been retained. By repeating this process, a set of results was obtained showing the effect of aging the neoprene latex before compounding and aging the neoprene compound itself. The results of these tests are given in Table 1.

A study of this table shows a substantial variation in the tensile strength and elongation of the films. There is little variation in modulus and in tear strength, but there appears to be some evidence that maturing the latex itself or the compound tends to result in more constant properties for the film. This one set of results cannot be considered conclusive, however; and another set will be evaluated during the next quarter.

TABLE 1

EFFECT OF AGING NEOPRENE LATEX AND NEOPRENE LATEX COMPOUNDS ON PHYSICAL PROPERTIES OF CURED FILMS

Latex Age before Compound.	Comp. Age before Dipping	Cure (min. @ 280°C)	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)	Tear Strength (lbs/in)
Fresh	Fresh	60	140	170	300	1950	940	74
		90	145	185	300	2025	910	71
		120	150	190	305	2085	905	71
Fresh	30 days	60	135	180	250	1535	895	75
		90	130	170	265	1845	935	67
		120	140	175	260	1820	925	64
Fresh	45 days	60	155	215	420	2150	835	70
		90	160	215	440	2395	845	63
		120	165	235	490	2305	830	78
Fresh	60 days	60	145	190	300	2245	915	80
		90	140	185	300	2430	925	69
		120	140	195	320	2380	905	67
Fresh	75 days	60	165	200	375	2850	950	89
		90	180	210	405	2835	915	89
		120	190	225	495	2680	865	87
30 days	Fresh	60	145	185	310	2885	975	89
		90	150	190	320	2945	985	75
		120	155	210	365	2490	935	93
30 days	15 days	60	145	200	365	1995	865	65
		90	150	220	360	2080	865	71
		120	160	215	485	2210	825	78
30 days	30 days	60	140	185	310	2135	900	63
		90	150	200	340	2300	895	72
		120	155	205	355	2605	890	73
30 days	45 days	60	185	215	415	2785	915	86
		90	185	215	450	2705	895	88
		120	195	225	470	2855	880	86
45 days	Fresh	60	140	190	325	2230	920	69
		90	140	195	345	2460	915	73
		120	155	205	445	2520	880	74
45 days	15 days	60	145	195	310	2480	915	67
		90	140	190	305	2420	895	72
		120	145	195	335	2470	905	75
45 days	30 days	60	195	230	465	3195	920	84
		90	180	210	420	3050	920	81
		120	180	225	505	3120	895	80
60 days	Fresh	60	150	195	315	2435	935	71
		90	150	200	325	2240	900	74
		120	150	195	355	2365	885	73
60 days	15 days	60	180	210	405	3015	935	86
		90	185	215	435	3035	915	83
		120	190	225	495	2740	875	80
75 days	Fresh	60	175	205	390	2970	945	80
		90	185	220	470	2785	895	78
		120	180	220	465	3110	915	88

FACTUAL DATA (continued)

TASK A, Phase 2 (continued)

Part B: Plasticizers

No progress during this period.

Part C: Antioxidants and Antiozonants

No progress during this period.

Part D: Accelerators

It has been customary throughout this study to use one part of accelerator for 100 parts of neoprene in all experimental formulae. It was considered of interest to determine the effect of varying the amount of accelerator, and two accelerators (Merac and Accelerator 833) were selected for this investigation.

Eight compounds were prepared, four containing 0.5, 1.0, 2.0, and 3.0 parts of Merac, respectively, and four containing similar parts of Accelerator 833. The formulations for these compounds are given in Table 2.

Plates were dipped from these compounds according to standard procedure and cured for 60, 90, and 120 minutes at 240°F, 260°F, and 280°F. Physical properties were determined at room temperature and at -40°C at those cures which are normally considered optimum for each of these compounds with one part of accelerator. The results of these tests are given in Tables 3, 4, and 5.

A study of the tables shows that Merac is an extraordinarily flat-curing accelerator. The room-temperature physical properties show virtually no change with 0.5, 1.0, 2.0, or 3.0 parts in the compound or at any cure time and temperature tested other than the 240°F cures. This is unquestionably a very desirable property in a balloon compound because of the difficulties associated with exposing the whole surface of a balloon to the same temperature for the same time.

The behavior of Accelerator 833 is unexpected and most interesting. While this accelerator is relatively flat curing at any one concentration, variations in the amount of accelerator produce considerable variations in physical characteristics. It is particularly noteworthy that increasing the amount of accelerator in the compound substantially increases the room-temperature elongation and reduces the modulus.

TABLE 2

FORMULATIONS OF COMPOUNDS CONTAINING VARYING QUANTITIES OF MERAC AND ACCELERATOR 833

Formulation No.	A2d-5	A2d-6	A2d-7	A2d-8	A2d-9	A2d-10	A2d-11	A2d-12
Neoprene 750	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Neoprene 571	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Zinc Oxide	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Neozone 'D'	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
N.B.C.	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Sunaptic Acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Aquarex SMO	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Dibutyl Sebacate	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25
Merac	0.5	1.0	2.0	3.0	-	-	-	-
Accelerator 833	-	-	-	-	0.5	1.0	2.0	3.0

FACTUAL DATA (continued)

TASK A, Phase 2, Part D (continued)

TABLE 3

PHYSICAL PROPERTIES OF COMPOUNDS A2d-5, A2d-6, A2d-7, AND A2d-8
TESTED AT ROOM TEMPERATURE

Compound No.	Cure Time (mins)	Cure Temp. (°F)	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)	Tear Strength (lbs/in)
A2d-5	60	240	120	185	315	1385	900	67
	90	240	125	185	335	1630	900	62
	120	240	135	205	390	1750	870	70
	60	260	155	200	420	2140	880	62
	90	260	155	210	430	2090	880	64
	120	260	165	220	435	2135	860	64
	60	280	170	215	385	1815	860	72
	90	280	165	215	405	2230	865	77
	120	280	160	220	390	2210	870	71
A2d-6	60	240	135	195	375	1600	930	55
	90	240	155	210	415	1885	875	65
	120	240	160	215	420	1885	865	64
	60	260	160	230	425	2045	880	62
	90	260	160	215	420	1980	870	68
	120	260	160	225	425	2100	870	67
	60	280	155	215	400	1920	880	63
	90	280	160	215	400	2020	870	77
	120	280	155	210	405	1870	850	82
A2d-7	60	240	145	210	395	1700	880	71
	90	240	150	210	415	1830	860	84
	120	240	150	215	420	1950	850	76
	60	260	155	215	430	1970	870	59
	90	260	160	215	430	2050	860	57
	120	260	155	220	430	2115	860	59
	60	280	150	200	390	1975	880	72
	90	280	140	205	385	2100	875	69
	120	280	140	200	395	2015	860	68
A2d-8	60	240	140	205	380	1735	880	67
	90	240	140	205	410	1730	860	70
	120	240	150	210	420	1830	845	70
	60	260	140	210	420	2085	870	62
	90	260	140	220	425	2085	870	62
	120	260	140	220	420	2115	880	58
	60	280	140	200	395	1685	875	62
	90	280	140	200	390	1840	360	62
	120	280	140	200	385	1700	840	62

FACTUAL DATA (continued)

TASK A, Phase 2, Part D (continued)

TABLE 4

PHYSICAL PROPERTIES OF COMPOUNDS A2d-9, A2d-10, A2d-11, AND A2d-12
TESTED AT ROOM TEMPERATURE

Compound No.	Cure Time (mins)	Cure Temp. (°F)	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)	Tear Strength (lbs/in)
A2d-9	60	240	135	185	320	1500	970	63
	90	240	155	200	355	1650	910	63
	120	240	160	205	365	1725	870	62
	60	260	155	210	365	1790	890	66
	90	260	160	220	385	1800	875	65
	120	260	165	225	370	1915	870	64
	60	280	150	185	305	1700	870	63
	90	280	155	185	335	1890	880	68
	120	280	150	185	330	1780	870	61
A2d-10	60	240	90	130	220	1430	1140	57
	90	240	110	150	240	1600	1075	58
	120	240	125	170	280	1750	975	56
	60	260	135	180	315	1920	960	60
	90	260	140	180	325	1930	940	60
	120	260	145	180	330	1990	935	58
	60	280	145	190	295	2030	980	68
	90	280	150	200	325	2100	940	73
	120	280	155	200	335	2115	900	73
A2d-11	60	240	70	125	230	1340	1155	47
	90	240	85	130	235	1535	1135	47
	120	240	100	140	245	1545	1100	50
	60	260	110	145	195	1765	1170	50
	90	260	110	135	200	1635	1140	51
	120	260	120	150	205	1845	1125	51
	60	280	130	160	205	1890	1210	62
	90	280	135	170	230	2200	1080	75
	120	280	140	180	290	2315	970	80
A2d-12	60	240	75	110	190	1350	1235	50
	90	240	85	115	210	1370	1185	55
	120	240	90	125	215	1505	1145	55
	60	260	105	135	175	1885	1200	58
	90	260	115	135	190	1860	1170	63
	120	260	120	140	190	1955	1170	58
	60	280	115	140	180	1780	1260	62
	90	280	120	140	180	1845	1240	59
	120	280	130	160	220	1915	1090	62

TABLE 5

PHYSICAL PROPERTIES OF COMPOUNDS A2d-5 THROUGH A2d-12
TESTED AT -40°C

Compound No.	Cure Time (mins)	Cure Temp. (°F)	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elongation at Break (%)
A2d-5	90	260	285	660	3390	3685	610
A2d-6	90	260	265	510	3545	4100	650
A2d-7	90	260	230	490	2880	4950	670
A2d-8	90	260	210	485	2625	5050	700
A2d-9	120	280	280	1125	5000	610	5340
A2d-10	120	280	255	575	3820	630	4540
A2d-11	120	280	265	510	2525	680	4500
A2d-12	120	280	230	485	2350	700	3675

It must also be noted that increasing the amount of both accelerators results in higher elongation at -40°C accompanied by a lowering of the modulus. There appear to exist, therefore, the possibilities of increasing balloon altitudes by this means.

Part E: Polymers other than Neoprene

No progress during this period.

Part F: Reinforcing Fillers

The use of carbon black confers excellent physical properties on a balloon film compound but is prejudicial to day flights because of its high infra-red radiation absorption. It was therefore decided to investigate Mistron Vapor, a very fine-particle-size talc, manufactured by The Sierra Talc Company.

FACTUAL DATA (continued)

TASK A, Phase 2, Part F (continued)

Three compounds containing Mistron Vapor were prepared, the formulations of which are given in Table 6. Plates were dipped from these compounds according to standard procedure and cured for 60, 90, and 120 minutes at 280°F. Physical properties were determined at room temperature and at -40°C, and the results of these tests are given in Table 7.

A study of these results shows that inclusion of Mistron Vapor in the compound results in a substantial increase in the modulus of the compound. The tensile strength is also increased, although to a lesser degree, and there is a relatively small loss in elongation.

At -40°C, there is an increase in the modulus at 200%, but the modulus at 400% and 600% and the tensile strength show relatively little change as does the elongation. It would appear, therefore, that Mistron Vapor can satisfactorily be used to increase the modulus of neoprene balloon compounds and that this characteristic might be of considerable value in the design of fast-rising balloon compounds.

Initial tests were made with zinc resinate obtained under the tradename of Zirex-BG-6566-01 from Newport Industries. This material contains approximately 10% zinc and was found to be soluble in Dibutyl Sebacate to the extent of 15 parts per hundred.

In a compound containing even as much as 25 parts of Dibutyl Sebacate it would, therefore, only be possible to incorporate about 4 parts of zinc resinate, which means that the zinc content of the compound would be 0.4%. This quantity is known to be too little.

The melting point of zinc resinate is too high to enable a hot emulsion to be made, and the use of a volatile solvent was not considered suitable for preparing emulsions for use in balloon compounds because of the extreme danger of porosity in the vulcanized film.

In addition to the above, the resinous nature of the material renders the neoprene film extremely tacky. Since the purpose of using zinc resinate was to eliminate a solid dispersion of zinc oxide and replace it with an emulsion, there was no point in attempting to make a zinc resinate dispersion; and in view of the attendant problems and disadvantages, no further work is planned with this material.

TABLE 6

FORMULATIONS OF COMPOUNDS CONTAINING MISTRON VAPOR

Formulation No.	A2f-1	A2f-2	A2f-3
Neoprene 750	80.0	80.0	80.0
Neoprene 571	20.0	20.0	20.0
Zinc Oxide	5.0	5.0	5.0
Neozone 'D'	2.0	2.0	2.0
N.B.C.	3.0	3.0	3.0
Accelerator 833	1.0	1.0	1.0
Sunaptic Acid	1.0	1.0	1.0
Aquarex SMO	0.5	0.5	0.5
Dibutyl Sebacate	6.25	6.25	6.25
Mistron Vapor	5.0	10.0	15.0

FACTUAL DATA (continued)

TASK A, Phase 2, Part F (continued)

TABLE 7

PHYSICAL PROPERTIES OF COMPOUNDS A3-105, A2f-1, A2f-2, AND A2f-3
TESTED AT ROOM TEMPERATURE AND AT -40°C

Compound No.	Test Temp. (°C)	Cure Time (mins)	Cure Temp. (°F)	Modulus at 200% (psi)	Modulus at 400% (psi)	Modulus at 600% (psi)	Tensile Strength (psi)	Elong. at Break (%)	Tear Strength (lbs/in)
A3-105	+20	60	280	125	170	280	2020	940	71
	+20	90	280	135	175	300	2150	925	74
	+20	120	280	135	185	325	2200	900	72
A2f-1	+20	60	280	180	265	520	2165	920	91
	+20	90	280	185	270	580	2340	900	91
	+20	120	280	195	275	620	2440	870	100
A2f-2	+20	60	280	210	310	625	2200	900	112
	+20	90	280	215	315	640	2430	920	107
	+20	120	280	220	335	725	2430	880	107
A2f-3	+20	60	280	265	415	870	2700	920	133
	+20	90	280	270	440	900	2790	875	138
	+20	120	280	275	445	900	2600	865	124
A3-105	-40	60	280	420	760	3820	4680	650	-
	-40	90	280	480	820	4000	4410	620	-
	-40	120	280	510	810	3920	4380	620	-
A2f-1	-40	60	280	510	850	4200	4370	610	-
	-40	90	280	535	1020	3990	3990	600	-
	-40	120	280	690	1450	4100	4230	610	-
A2f-2	-40	60	280	620	1760	4160	4400	610	-
	-40	90	280	680	2100	5300	5525	620	-
	-40	120	280	760	1840	3960	3960	600	-
A2f-3	-40	60	280	880	2220	4390	5100	620	-
	-40	90	280	1010	1890	-	5370	590	-
	-40	120	280	1020	2140	-	5260	590	-

Phase 3: Development of Formulations with Desirable Film Properties

Part A: High-Altitude Balloon Compounds

No progress during this period.

Part B: Dual-Purpose Balloon Compounds

In view of the promising results shown during the evaluation of Merac, three compounds were designed. One of them is a day-flight compound (A3-132) and the other two (A3-135 and A3-136) are dual-purpose compounds. The formulations for these compounds are as follows:

	A3-132	A3-135	A3-136
Neoprene 750	80.0	80.0	80.0
Neoprene 571	20.0	20.0	20.0
Zinc Oxide	5.0	5.0	5.0
Neozone 'D'	2.0	2.0	2.0
N.B.C.	3.0	3.0	3.0
Accelerator 833	-	0.5	-
Merac	1.0	0.5	1.0
Sunaptic Acid	1.0	1.0	1.0
Aquarex SMO	0.5	0.5	0.5
Dibutyl Sebacate	6.25	6.25	6.25
Paraflux C-325	-	22.5	22.5

The purpose of compound A3-135 was to determine the effect of using a blend of two accelerators, such conditions not having been previously studied in this research. Since the optimum cure has already been established for compounds containing Merac, the physical properties of these compounds were determined at that cure only. The results follow:

	Balloon from A3-132	
Test temperature ($^{\circ}$C)	+20	-40
Modulus at 200% (psi)	140	405
Modulus at 400% (psi)	200	1165
Modulus at 600% (psi)	365	3100
Tensile Strength (psi)	2150	4275
Elongation (%)	980	710
Tear Strength (lbs/in)	73	-

FACTUAL DATA (continued)

TASK A, Phase 3, Part B (continued)

	Balloon from A3-135	
Test temperature (°C)	+20	-70
Modulus at 200% (psi)	115	1170
Modulus at 400% (psi)	195	3000
Modulus at 600% (psi)	415	-
Tensile Strength (psi)	1340	4410
Elongation (%)	800	545
Tear Strength (lbs/in)	47	-

	Balloon from A3-136	
Test temperature (°C)	+20	-70
Modulus at 200% (psi)	105	1040
Modulus at 400% (psi)	180	2970
Modulus at 600% (psi)	355	-
Tensile Strength (psi)	1460	5210
Elongation (%)	820	530
Tear Strength (lbs/in)	52	-

It is clear from these results that balloons made from compounds A3-135 and A3-136 should be satisfactory at the 100,000-foot level but cannot be expected to be superior to balloons made from A3-106. The higher modulus indicates a satisfactory rate of ascent.

Day-flight balloons made from compound A3-132 should be equal, of not slightly superior, to those made from compound A3-105. Balloons were, therefore, submitted for flight testing, and the results of the flights are given in Task A, Phase 4, Part B of this report.

In the Fifth Quarterly Report, compound A3-131 was described. This compound contained Neoprene 400 and Dibutyl Sebacate as the only plasticizer since difficulties in incorporating Butyl Oleate into Neoprene 400 latex were encountered. It

FACTUAL DATA (continued)

TASK A, Phase 3, Part B (continued)

proved impossible to make balloons from this compound because the gel was much too soft to handle in every way; therefore, work on this compound was discontinued.

It was, however, found possible to use Dibutyl Sebacate as the only plasticizer in a compound containing Sulphur and Neoprene 571. The formulation for this compound and its optimum physical properties are given below:

	Compound A3-133
Neoprene 750	80.0
Neoprene 571	10.0
Neoprene 735	10.0
Zinc Oxide	5.0
Neozone 'D'	2.0
N.B.C.	3.0
Accelerator 833	1.0
Sunaptic Acid	1.0
Aquarex SMO	0.5
Sulphur	5.0
Dibutyl Sebacate	25.0

	Balloon from A3-133	
Test temperature (°C)	+20	-70
Modulus at 200% (psi)	110	
Modulus at 400% (psi)	245	FROZEN
Modulus at 600% (psi)	470	
Tensile Strength (psi)	1365	
Elongation (%)	825	
Tear Strength (lbs/in)	42	

These results confirm the necessity for using Butyl Oleate, Paraflux C-325, or Butoxy Ethyl Oleate as a low-temperature plasticizer. Nevertheless, it was decided to fly balloons made from this compound, and the results of these flights are given in Task A, Phase 4, Part B of this report.

FACTUAL DATA (continued)

TASK A, Phase 3, Part B (continued)

Results obtained with Mistron Vapor (see Task A, Phase 2, Part F) suggest that improved rates of ascent might be obtained in dual-purpose compounds which contain this material because of the higher modulus it yields. At the same time, there should be no loss in altitude since the elongation is relatively unaffected. Accordingly, compound A3-137 was designed, the formulation and physical properties of which follow:

	Compound A3-137
Neoprene 750	80.0
Neoprene 571	20.0
Mistron Vapor	10.0
Zinc Oxide	5.0
Neozone 'D'	2.0
N.B.C.	3.0
Accelerator 833	1.0
Sunaptic Acid	1.0
Aquarex SMO	0.5
Dibutyl Sebacate	6.25
Paraflux C-325	22.5

	Balloon from A3-137	
Test Temperature (°C)	+20	-70
Modulus at 200% (psi)	130	1320
Modulus at 400% (psi)	190	3690
Modulus at 600% (psi)	425	-
Tensile Strength (psi)	1500	5280
Elongation (%)	810	520
Tear Strength (lbs/in)	55	-

As anticipated, the room temperature modulus is substantially higher than that of compound A3-106, yet the elongation at both room temperature and at -70°C is not reduced. Accordingly, balloons were made from this compound, and their flight performance is recorded in Task A, Phase 4, Part B of this report.

FACTUAL DATA (continued)

TASK A, Phase 3 (continued)

Part C: Fast-Rise Balloon Compounds

Mistron Vapor's ability to raise modulus without reducing elongation suggests that it would produce an excellent high-modulus, fast-rise balloon compound. Accordingly, a day-flight compound (A3-134) was designed, and its formulation and physical properties are given below:

	Compound A3-134
Neoprene 750	80.0
Neoprene 571	20.0
Mistron Vapor	10.0
Zinc Oxide	5.0
Neozone 'D'	2.0
N.B.C.	3.0
Accelerator 833	1.0
Sunaptic Acid	1.0
Aquarex SMO	0.5
Dibutyl Sebacate	6.25

	Balloon from A3-134	
Test Temperature (°C)	+20	-40
Modulus at 200% (psi)	260	680
Modulus at 400% (psi)	415	2100
Modulus at 600% (psi)	920	5300
Tensile Strength (psi)	2915	5525
Elongation (%)	890	620
Tear Strength (lbs/in)	115	-

These results are as anticipated, and the modulus of this compound is greater than that of the sulphur-bearing, fast-rise compound A3-102. Balloons were therefore made from this compound for use in the construction of two-piece, streamlined balloons, the flight results of which are given in Task C, Phase 3.

In addition, balloons were post-plasticized for night flight, and the following physical properties were obtained on such a balloon film:

FACTUAL DATA (continued)

TASK A, Phase 3, Part C (continued)

	Balloon from A3-134 Post-Plasticized		
Test Temperature (°C)	+20	-40	-70
Modulus at 200% (psi)	150	760	1290
Modulus at 400% (psi)	240	1840	3020
Modulus at 600% (psi)	560	3960	-
Tensile Strength (psi)	1680	3960	4470
Elongation (%)	810	600	510
Tear Strength (lbs/in)	61	-	-

These results also indicate that good fast-rise balloons could be obtained, the room-temperature modulus still being very high. The fact that the film does not freeze at -70°C indicates that it will fly satisfactorily at night. Therefore, further balloons made from A3-134 were post-plasticized and used in the construction of fast-rise, night-flight balloons. The results of these flights are also recorded in Task C, Phase 3.

Phase 4: Correlation of Film Properties with Flight Data

Part A: High-Altitude Balloons

No progress during this period.

Part B: Dual-Purpose Balloons

In order to verify the performance of balloons made from compound A3-106, a further set of flights was conducted. Three groups of balloons were flown, each group consisting of six balloons. Balloons EX-3A-561 through EX-3A-566 were standard balloons which received the standard cure; balloons EX-3A-567 through EX-3A-572 were cured for two hours at 260°F; and balloons EX-3A-573 through EX-3A-578 had approximately 10% greater wall thickness.

Three balloons from each group were flown during the day, and three were flown at night. A free lift of 1600 grams was employed for all flights. The characteristics of these balloons and their flight results are given in Table 8.

TABLE 8

FLIGHT RESULTS - BALLOONS MANUFACTURED FROM COMPOUND A3-106

Experiment No.	Balloon No.	Day or Night Flight	Weight (grams)	Length (inches)	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
EX-3A-561	M17-1T	Night	985	110	14,500	833
EX-3A-562	M17-2T	Day	1090	112	100,200	937
EX-3A-563	M17-3T	Day	1045	108	95,240	904
EX-3A-564	M17-4T	Day	1035	110	96,000	1007
EX-3A-565	M17-5T	Night	1015	107	109,700	956
EX-3A-566	M17-6T	Night	1060	110	99,100	923
EX-3A-567	M26-1T	Day	1045	104	102,400	1021
EX-3A-568	M26-2T	Night	1110	108	97,790	939
EX-3A-569	M26-3T	Day	1050	107	105,300	986
EX-3A-570	M26-4T	Night	1095	108	54,900	678
EX-3A-571	M26-5T	Day	1105	107	101,300	968
EX-3A-572	M26-6T	Night	1095	106	100,500	925
EX-3A-573	M31-1T	Day	1185	110	97,300	925
EX-3A-574	M31-2T	Night	1200	112	98,680	934
EX-3A-575	M31-3T	Day	1210	109	89,800	912
EX-3A-576	M31-4T	Night	1195	112	102,400	873
EX-3A-577	M31-5T	Day	1210	111	70,000	955
EX-3A-578	M31-6T	Night	1195	107	124,500	1098

TASK A, Phase 4, Part B (continued)

A study of this table shows that the general level of performance of all these balloons is decidedly below that usually obtained with balloons made from compound A3-106. Of eighteen flights, only eight reached altitudes in excess of 100,000 feet, and the rates of ascent were extremely slow.

Compound A3-132 showed satisfactory physical properties. Two balloons made from this compound and eight made from the corresponding dual-purpose compound, A3-136, were submitted for flight testing. Because of the poor performance of the balloons made from A3-106, two further groups of balloons made from this compound were also flown.

Balloons EX-3A-591 and EX-3A-592 were made from compound A3-132, and balloons EX-3A-593 through EX-3A-600 were made from compound A3-136. Balloons EX-3A-601 through EX-3A-606 were made from A3-106 and subjected to eight hours heat aging before flight; balloons EX-3A-607 through EX-3A-612 were standard A3-106 balloons.

The characteristics of these balloons, which were all flown with a free lift of 1600 grams, and their flight performance are given in Table 9.

A study of these flights indicates that compounds A3-132 and A3-136 are equal in performance to A3-106. Furthermore, the good performance of balloons made from A3-106 is confirmed and the flights also indicate that there is no loss in performance after the balloons are subjected to accelerated aging.

Six balloons made from compound A3-129 were submitted for flight testing. A previous group of flights with balloons made from this compound had proved satisfactory and appeared to be slightly superior to flights with similar balloons made from compound A3-106.

These six balloons are identified as EX-3A-641 through EX-3A-646 and were flown with a free lift of 1600 grams. Their characteristics and flight performance are given in Table 10.

A study of these results shows that the performance of this compound has been confirmed, and it must be considered as another compound which will produce satisfactory 100,000-foot balloons.

FACTUAL DATA (continued)

TABLE 9

FLIGHT RESULTS - BALLOONS MANUFACTURED FROM COMPOUNDS A3-132, A3-136, A3-106

Experiment No.	Balloon No.	Compound No.	Day or Night Flight	Weight (grams)	Length (inches)	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
EX-3A-591	M28-1TK	A3-132	Day	810	92	95,240	1023
EX-3A-592	M28-2TK	A3-132	Day	795	90	97,100	1103
EX-3A-593	M28-3TK	A3-136	Night	870	97	95,240	949
EX-3A-594	M28-4TK	A3-136	Night	975	105	72,300	980
EX-3A-595	M28-6TK	A3-136	Night	910	107	110,335	1076
EX-3A-596	M27-1TK	A3-136	Night	940	100	98,000	939
EX-3A-597	M27-4TK	A3-136	Night	965	101	114,829	1041
EX-3A-598	M27-6TK	A3-136	Night	1020	108	100,400	900
EX-3A-599	M26-1TK	A3-136	Night	900	102	110,663	1063
EX-3A-600	M26-2TK	A3-136	Night	940	104	111,352	1047
EX-3A-601	R11-1T	A3-106	Day	1005	100	104,921	1017
EX-3A-602	R11-2T	A3-106	Day	1035	96	96,260	985
EX-3A-603	R11-3T	A3-106	Day	1005	97	84,400	912
EX-3A-604	R11-4T	A3-106	Night	1085	105	116,667	1095
EX-3A-605	R11-5T	A3-106	Night	1010	101	110,007	1055
EX-3A-606	R11-6T	A3-106	Night	1025	99	115,157	1040
EX-3A-607	R24-1T	A3-106	Day	1085	104	77,100	960
EX-3A-608	R24-2T	A3-106	Night	1075	103	103,600	1022
EX-3A-609	R24-3T	A3-106	Day	935	102	110,138	1065
EX-3A-610	R24-4T	A3-106	Night	1000	101	112,956	1075
EX-3A-611	R24-5T	A3-106	Day	1085	103	109,121	1040
EX-3A-612	R24-6T	A3-106	Night	1070	106	101,800	1055

TABLE 10

FLIGHT RESULTS - BALLOONS MANUFACTURED FROM COMPOUND A3-129

Experiment No.	Balloon No.	Day or Night Flight	Weight (grams)	Length (inches)	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
EX-3A-641	S12-1T	Night	1055	113	116,690	1051
EX-3A-642	S12-2T	Day	1015	112	113,000	1090
EX-3A-643	S12-3T	Night	1050	104	81,800	863
EX-3A-644	S12-4T	Day	1050	106	102,300	989
EX-3A-645	S12-5T	Night	1055	108	111,362	1057
EX-3A-646	S12-6T	Day	1020	110	101,000	1039

Six balloons made from compound A3-133 were submitted for flight testing. This compound employs Dibutyl Sebacate in place of Butyl Oleate because of the difficulties encountered in the making of compounds having high Butyl Oleate content. The gel proved to be difficult to handle, being much softer than similar gels in which Butyl Oleate is the plasticizer. All the balloons tended to be thinner than is considered desirable in the neck area. They were flown with a free lift of 1600 grams, and the characteristics of these balloons together with their flight performance are given in Table 11.

A study of these results shows that the performance is, in general, uniform and surprisingly good considering the appearance of the balloons and their poor low-temperature properties. However, the altitudes are generally low and unsatisfactory. Because of the difficulties of handling this compound in the gel stage, no further work with it is planned.

Six balloons made from compound A3-135 were submitted for flight testing. This compound contains a blend of two accelerators. The balloons were identified as EX-3A-631 through EX-3A-636 and were flown with a free lift of 1600 grams. The characteristics and flight performance are given in Table 12.

FACTUAL DATA (continued)

TASK A, Phase 4, Part B (continued)

TABLE 11

FLIGHT RESULTS - BALLOONS MANUFACTURED FROM COMPOUND A3-133

Experiment No.	Balloon No.	Day or Night Flight	Weight (grams)	Length (inches)	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
EX-3A-621	R21-2TK	Night	880	99	97,960	1026
EX-3A-622	R21-3TK	Night	895	99	98,130	1014
EX-3A-623	R21-4TK	Night	870	101	94,900	954
EX-3A-624	R22-5TK	Day	895	105	97,100*	1004
EX-3A-625	R22-6TK	Day	905	105	97,960	1008
EX-3A-626	R22-8TK	Day	865	98	103,600	1063

*Top Intelligible Data

TABLE 12

FLIGHT RESULTS - BALLOONS MANUFACTURED FROM COMPOUND A3-135

Experiment No.	Balloon No.	Day or Night Flight	Weight (grams)	Length (inches)	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
EX-3A-631	S21-2TK	Night	1070	98	96,200*	1006
EX-3A-632	S21-4TK	Day	1180	99	88,400	1130
EX-3A-633	S22-2TK	Day	1115	94	99,060	1075
EX-3A-634	S22-3TK	Night	1110	97	110,600	1134
EX-3A-635	S22-5TK	Night	1085	98	110,050	1110
EX-3A-636	S22-7TK	Day	1160	105	battery failure	

*Top Intelligible Data

FACTUAL DATA (continued)

TASK A, Phase 4, Part B (continued)

A study of these results shows that despite the somewhat shorter length of the balloons, the performance is quite satisfactory and the rates of ascent are unusually high. Additional flights with longer balloons made from this compound appear to be indicated.

Six balloons made from compound A3-137 were submitted for flight testing. This compound contains Mistron Vapor and has a higher modulus than dual-purpose compounds in general. The balloons were identified as EX-3A-651 through EX-3A-656 and were flown with a free lift of 1600 grams. Their characteristics and flight performance are given in Table 13.

A study of these results shows that the balloons performed satisfactorily and that the rate of ascent is substantially above 1000 feet per minute. These results can be anticipated from the physical characteristics of the compound.

The flights performed during this quarter have clearly demonstrated that if certain minimum physical properties of a compound are established at room temperature and at -70°C, then the performance of balloons made from such compounds can be accurately predicted at the 100,000-foot level.

TABLE 13

FLIGHT RESULTS - BALLOONS MANUFACTURED FROM COMPOUND A3-137

Experiment No.	Balloon No.	Day or Night Flight	Weight (grams)	Length (inches)	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
EX-3A-651	T5-1TK	Night	1350	108	111,385	1077
EX-3A-652	T5-2TK	Night	1225	110	102,800	1073
EX-3A-653	T5-3TK	Night	1220	109	109,252	1040
EX-3A-654	T5-4TK	Day	1170	110	Radiosonde Failure	
EX-3A-655	T6-1TK	Day	1170	112	103,300	1097
EX-3A-656	T6-2TK	Day	1180	114	98,200	1001

FACTUAL DATA (continued)

TASK A, Phase 4, Part B (continued)

It is now proposed to use the same or very similar compounds to make balloons designed to reach higher altitudes, e.g., at least 120,000 feet, and to establish the necessary criteria for performance at this and higher levels. Only when, as the result of the evaluation of new polymers or other raw materials, compounds are developed with radically different physical properties will their performance be checked out at the 100,000-foot level.

Part C: Fast-Rise Balloons

No work on one-piece, fast-rising balloons was conducted during this period.

TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON FILM PERFORMANCE

Phase 1: Effect of Pre-elongation

No progress during this period.

Phase 2: Effect of Ozone

No progress during this period.

Phase 3: Effect of Infra-Red Radiation

Measurements of the spectral characteristics of neoprene film of various thicknesses and color have been made for the near infrared region. A Beckman Instruments IR-5A infra-red spectrophotometer with NaCl prism was used to measure the transmittance in the wave length interval from 2 to 16 microns. Samples of white, rec, and black neoprene were stretched over sample holders to give thicknesses ranging from flaccid (3.3 mils) to 0.3 mils. The results of these measurements are summarized in Figures 1, 2, and 3.

Figure 1 (top) shows the percent transmittance of three thicknesses of white neoprene film, namely, 1.4, 0.83, and 0.5 mils. These three curves illustrate the increasing transmittance as the thickness of the film is decreased. Also, in the range of from 2 to 5 microns, the effect of scattering becomes less pronounced as the thickness is decreased.

Figure 1 (center) shows the percent reflectance of the same three samples. To make these measurements, a 30° indicence reflectance attachment to the IR-5A was used. This measure of the specular reflection at 30° does not include all of the reflected energy since there is also diffuse reflection, particularly in the region 2 to 5 microns. However, since no spectrophotometer is yet

available which will give the total reflectance in the infra-red, these measurements may be taken to give a qualitative indication of the minimum reflection over the spectral interval 2 to 16 microns.

The curve for 1.4 mils thickness shows very low reflection over the whole range with a small maximum of the order of 3% at 9 to 10 microns and beyond 13 microns. The thinner films indicate an increasing amount of reflection averaging about 4% for 0.83 mils and 5% for 0.5 mils.

Another interesting feature of these curves is the marked interference pattern produced by reflection from the top and bottom surfaces of the film. These interference patterns can be used to determine the thickness of the film with great accuracy. The formula for this determination is

$$d = \frac{n}{2}\left(\frac{l_2 \cdot l_1}{l_2 - l_1}\right)$$

where n is the number of waves

l_2 and l_1 are the wave lengths in units of length

d is the thickness of the film in the same units

Figure 1 (bottom) indicates the absorptivity of the same three samples. The absorptivity was computed according to

$$A\% = 100 - T\% - R\%$$

where A is the absorptivity

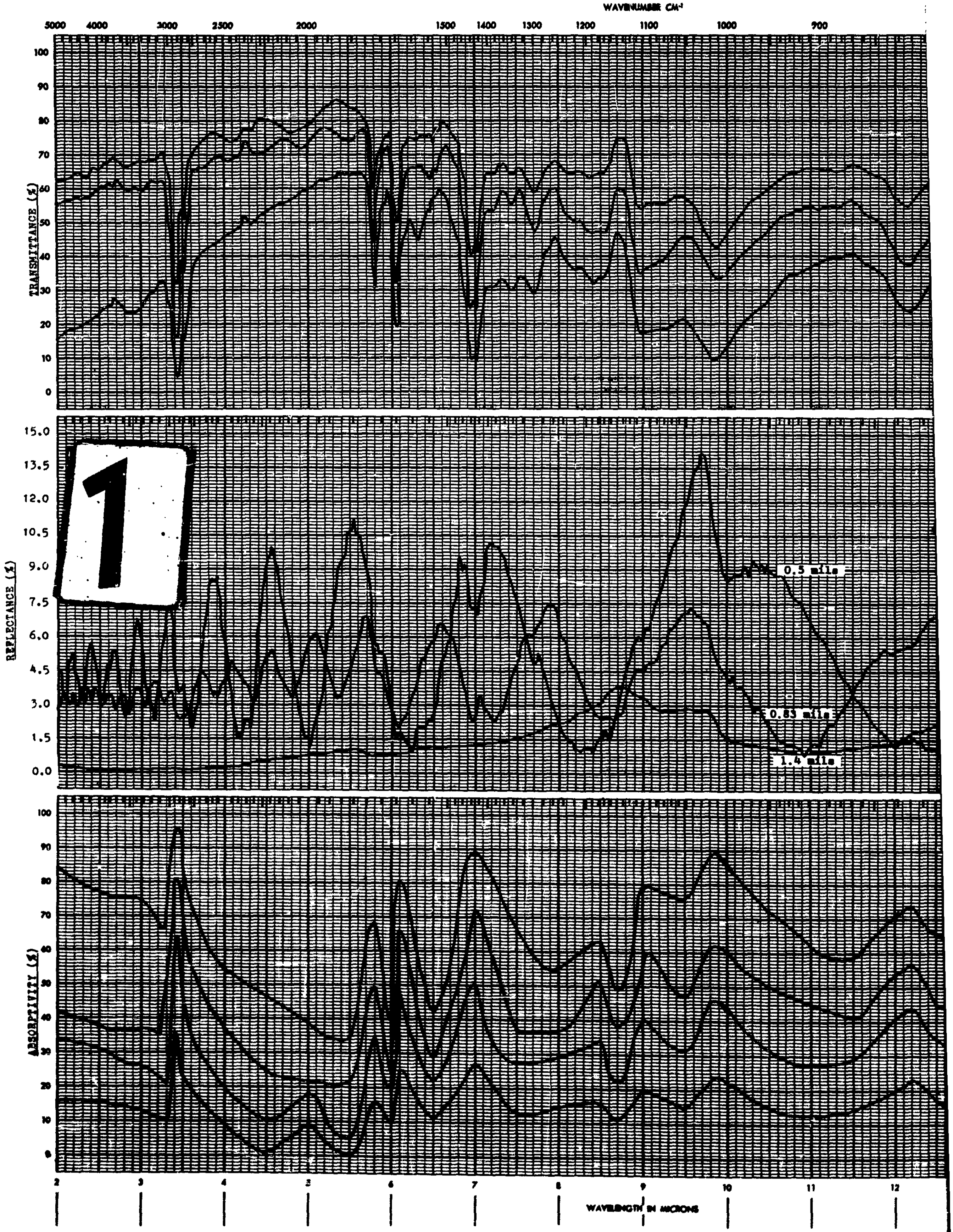
T is the transmissivity

R is the reflectivity.

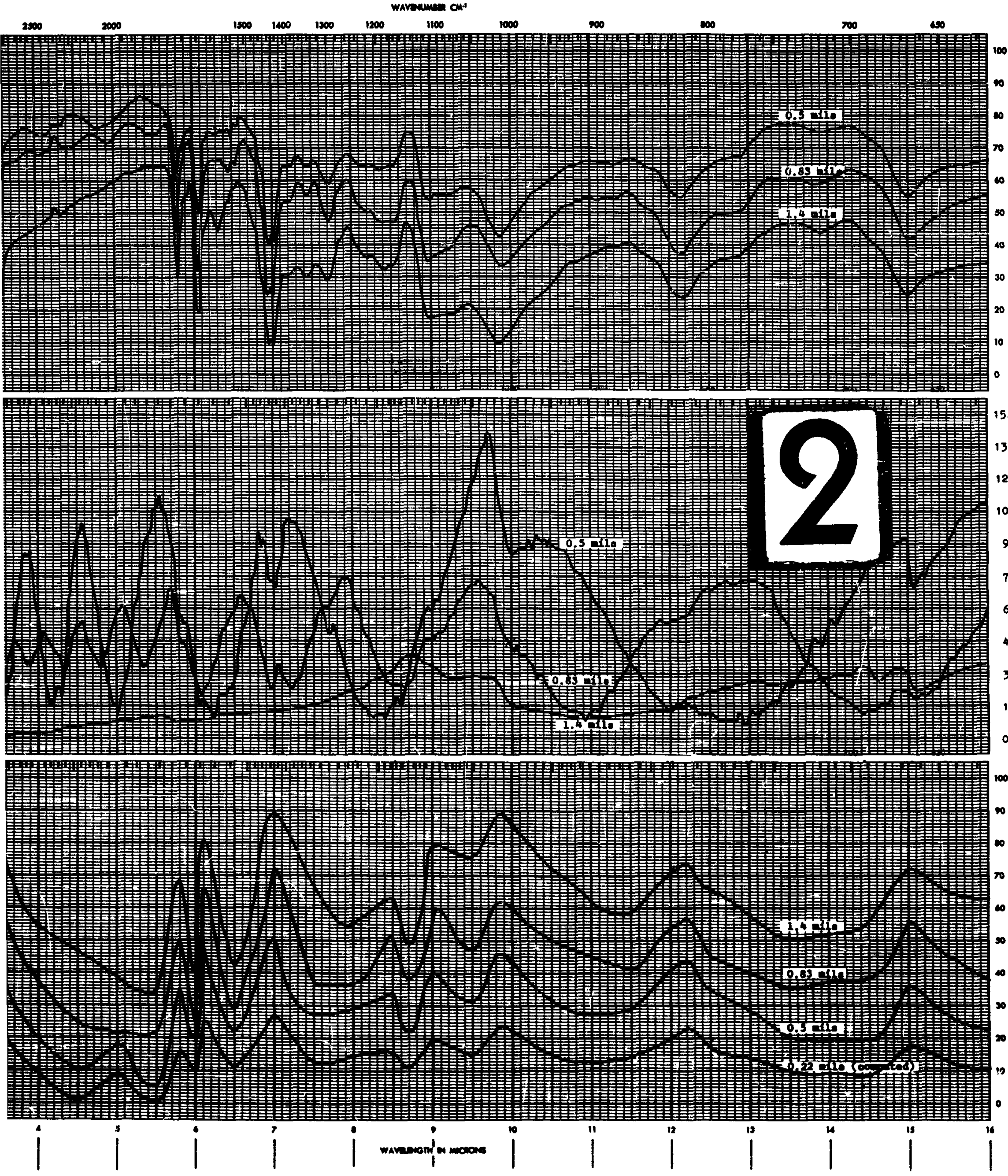
Whereas Figure 1 (top and center) are copies of the spectrometer charts, the curves on Figure 1 (bottom) are smoothed to indicate the important features only.

In addition to the absorptivity curves for the samples of 1.4, 0.83, and 0.5 mils thick, computations using these values of absorptivity were made to test the applicability of Beers' Law. It was found that the absorptivity as a function of thickness did indeed satisfy this condition to within experimental errors. On the basis of this, another absorptivity curve for a thickness of 0.22 mils was computed and drawn. This curve is also shown on Figure 1 (bottom).

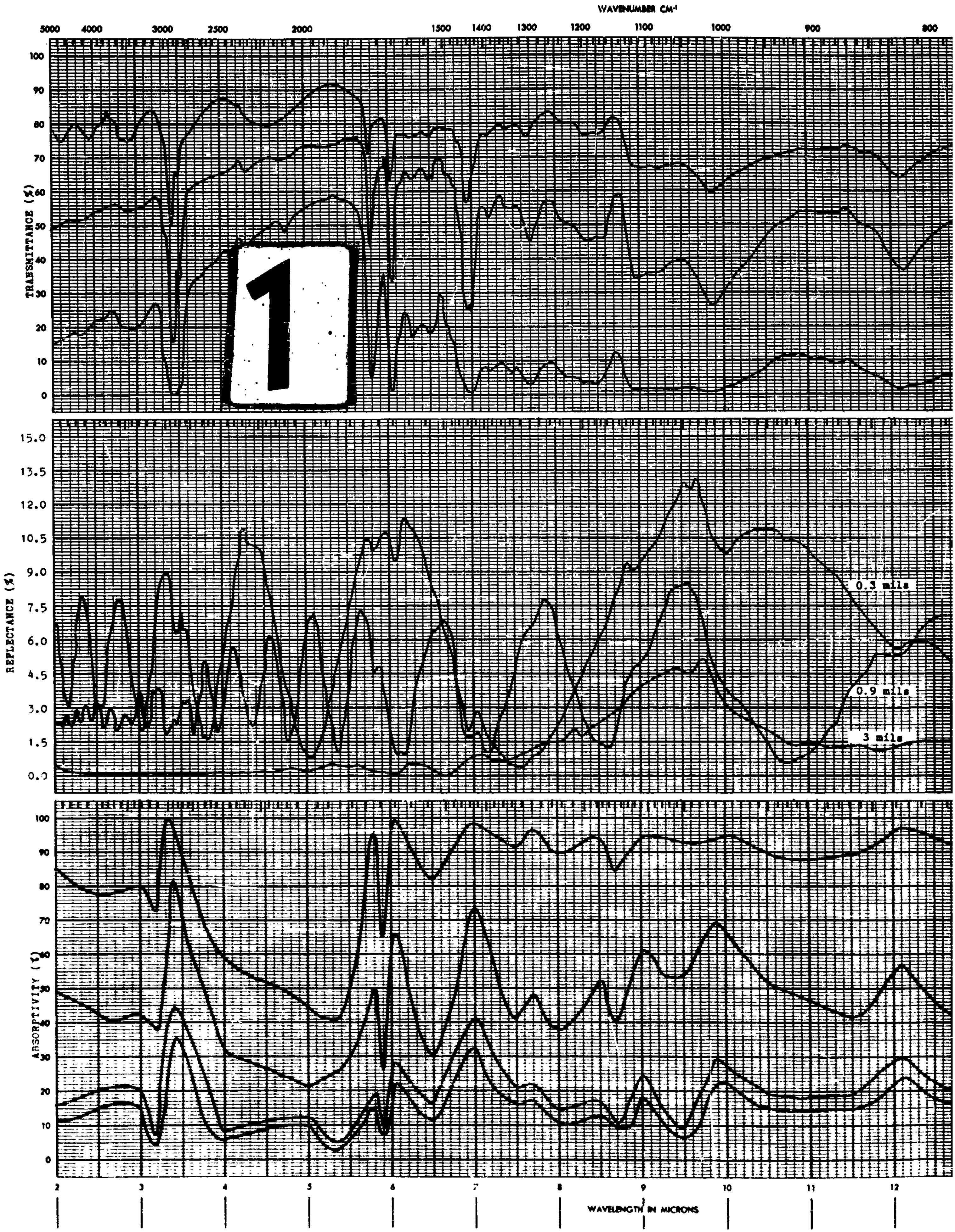
SPECTRAL TRANSMITTANCE, REFLECTANCE, AND ABSORPTIVITY IN PERCENT FOR WHITE NEOPRENE FILMS OF VARIOUS THICKN



SPECTRAL TRANSMITTANCE, REFLECTANCE, AND ABSORPTIVITY IN PERCENT FOR WHITE NEOPRENE FILMS OF VARIOUS THICKNESSES



SPECTRAL TRANSMITTANCE, REFLECTANCE, AND ABSORPTIVITY IN PERCENT FOR RED NEOPRENE FILMS OF VARIOUS THICKNESSES



SPECTRAL TRANSMITTANCE, REFLECTANCE, AND ABSORPTIVITY IN PERCENT FOR RED NEOPRENE FILMS OF VARIOUS THICKNESSES

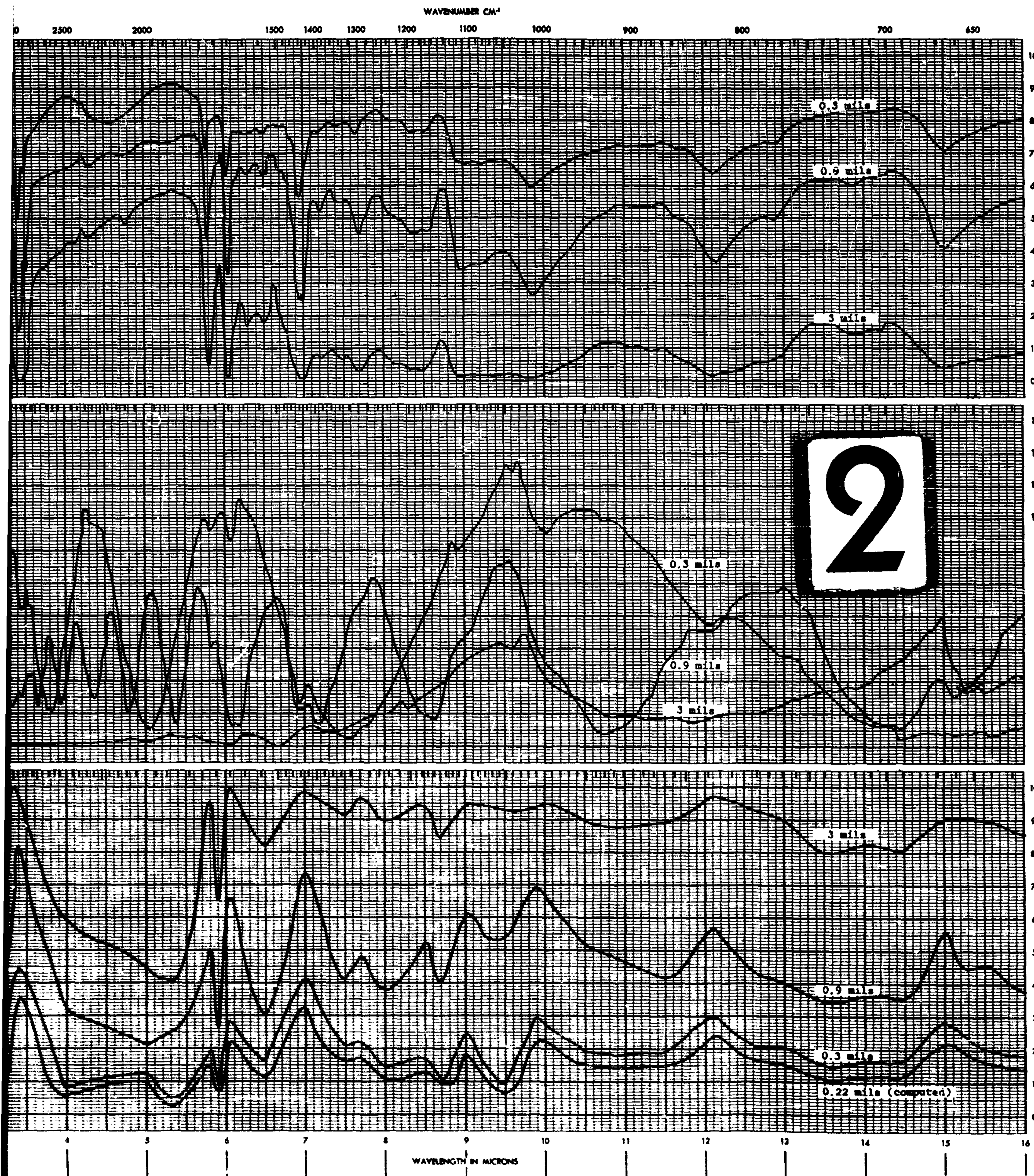
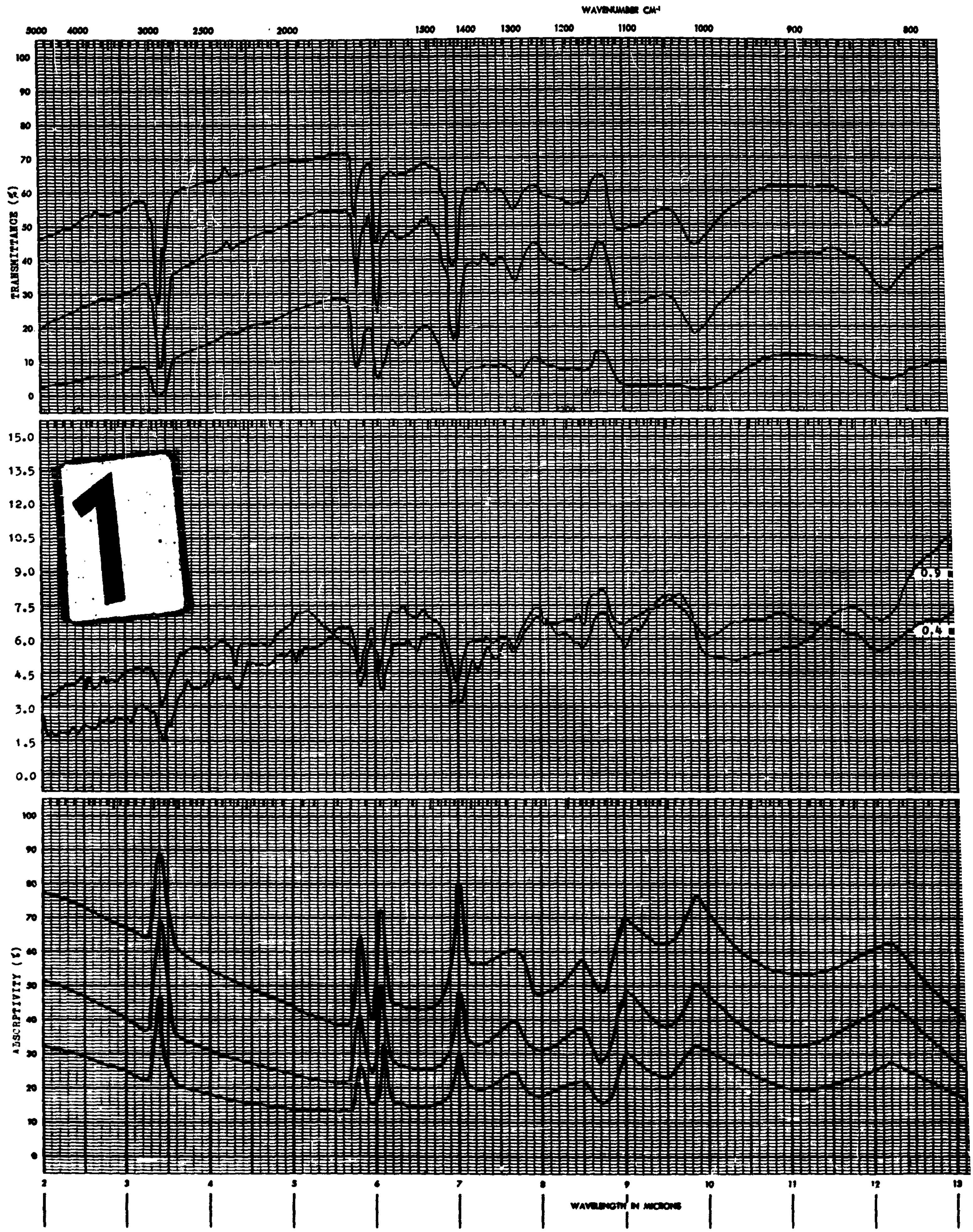
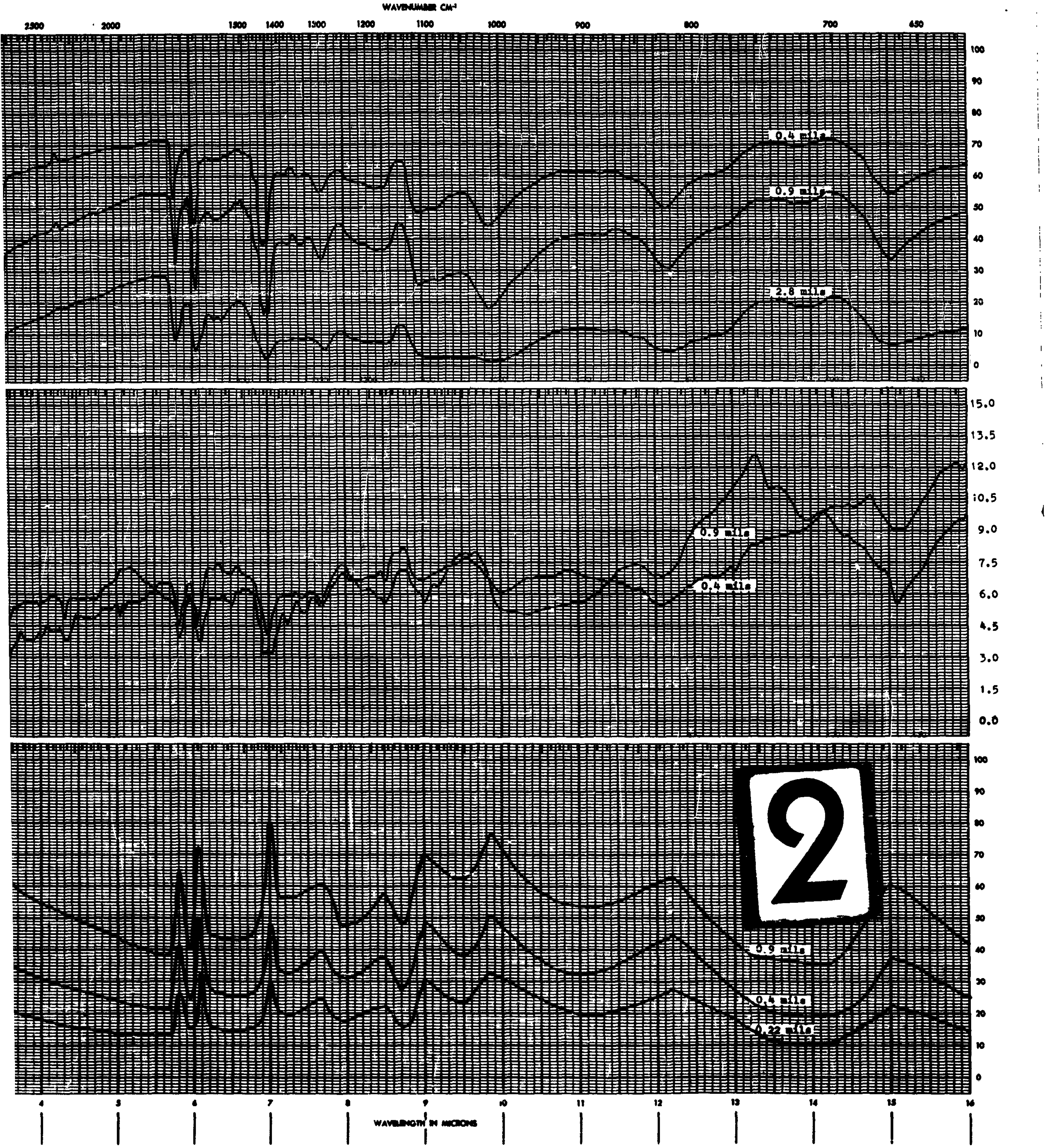


FIGURE 2

SPECTRAL TRANSMITTANCE,
REFLECTANCE, AND
ABSORPTIVITY IN PERCENT
FOR RED NEOPRENE FILMS
OF VARIOUS THICKNESSES

... BLACK NEOPRENE FILMS OF VARIOUS THICKNESSES





WAVENUMBER CM-1
2500
2000
1500
1400
1300
1200
1100
1000
900
800
700
650
0.4 mils
0.9 mils
2.8 mils
100
90
80
70
60
50
40
30
20
10
0
15.0
13.5
12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
0.9 mils
0.4 mils
2
0.9 mils
0.4 mils
0.22 mils
4
5
6
7
8
9
10
11
12
13
14
15
16
WAVELENGTH IN MICRONS

FIGURE 3

SPECTRAL TRANSMITTANCE,
REFLECTANCE, AND
ABSORPTIVITY IN PERCENT
FOR BLACK NEOPRENE FILMS
OF VARIOUS THICKNESSES

TASK B, Phase 3 (continued)

The value 0.22 mils was used to approximate the thickness of a balloon four times its initial radius. This corresponds to an elevation of about 80,000 to 90,000 feet. By way of comparison, this curve agrees essentially with Figure 4, page xi, of the report, "The Radiation Load on a Balloon in the Free Atmosphere" (see Report No. 4, Task B, Phase 3, April 24, 1961), on the basis of which computations on the radiative equilibrium temperature of a balloon were made. Since the new curve agrees so well with the extrapolated curve in the preceding report, the computed temperatures still stand.

Figure 2 is a set of similar transmittance, reflectance, and absorptivity curves for neoprene balloon film colored red. In all essential features, the near infra-red characteristics of the red neoprene are the same as those for white neoprene discussed above.

Figure 3 is a similar set of transmittance, reflectance, and absorptivity curves for black neoprene film. These curves show the same basic absorption bands as the white and red neoprene. However, a striking difference is also apparent.

Over all, the transmissivity of the black neoprene is less than the white or red neoprene. Scattering is still important in the range 2 to 5 microns. This is true even with the film 0.4 mils thick. The reflectivity is also markedly different from the red and white neoprene. No interference patterns are apparent and the average reflectivity of the 0.4 and 0.9 mil black neoprene is higher than the white or red.

When the transmittance and reflectance values are added to deduce the absorptivity, it is found that the absorptivity of the black neoprene is consistently greater than that for the white and red neoprene films over the whole range 2 to 16 microns. This is particularly true in the region 2 to 6 microns and 7 to 14 microns.

The absorptivity of the black neoprene is about 1.5 times the absorptivity of the white or red neoprene in the region 9 to 11 microns. This is of particular importance since it is in this region that the terrestrial radiation is a maximum.

Spectrophotometers capable of making measurements of transmittance in the spectral range 16 to 40 microns have recently become available. It will now be possible to measure the spectral transmittance of the neoprene film in this region which encompasses about one half of the terrestrial radiation. These measurements on films of various thicknesses together with corresponding measurements in the ultra-violet, visible, and near infra-red of the total transmittance and reflectance will permit a more accurage determination of the radiative equilibrium temperatures according to the procedure outlined in the preceding report.

FACTUAL DATA (continued)

TASK B (continued)

Phase 4: Effect of Ultra-Violet and Other Short-Wave Radiation

As reported previously (see Report No. 4), exposure to radiation from a Hanovia ultra-violet lamp with maximum radiation at 3600 A° had no effect on neoprene balloon films. This was true in an atmosphere of air or nitrogen and was independent of inclusion of antiozonants in the neoprene compound.

Therefore, a bulb having maximum radiation at 2800 A° was obtained. This is a G.E. bulb No. G4-S11 which was mounted in series with a suitable ballast. Preliminary experiments showed again that exposure to ultra-violet radiation of this wave length has no effect on neoprene balloon films.

In order to explore this further, three more of the same type of lamp have been purchased. This will enable the increase in intensity of the radiation, and work along these lines is being continued.

Phase 5: Correlation of Physical Properties with Flight Performance

No progress during this period.

Phase 6: Prediction of Balloon Performance

Part A: Determination of Burst Altitude from Residual Elongation

No progress during this period. This study was completed, and a report of the findings is given in the Third Quarterly Report.

Part B: Determination of Dimensions of Fast-Rising Balloons

The dimensions of fast-rising balloons designed to reach altitudes of 75,000 and 100,000 feet were theoretically determined. The performance of an ML-518 balloon was taken as a basis for the following calculations. Such a balloon weighs 800 grams excluding the stem assembly and has a flaccid length of 100 inches. Its gauge ranges from .003" to .0035". When flown with a total lift of 3700 grams, it reaches an altitude of 100,000 feet or more in the daytime.

It has been shown that a fast-rising balloon should have a wall thickness of at least twice and preferably three times that of a standard sounding balloon. Therefore, if the length is maintained at 100 inches, a balloon having a wall thickness of .009" to .010" would weigh 2400 grams, since the weight would be proportional to the thickness.

FACTUAL DATA (continued)

TASK B, Phase 6, Part B (continued)

To this must be added the weight of the tail. If a standard gauge ML-518 type is used for this purpose, an additional weight of 600 grams may be assumed since approximately one quarter of the tail balloon is removed before affixing it to the balloon proper. The weight of the assembly, therefore, would be 3000 grams, which is 2200 grams more than that of an ML-518 balloon.

It is customary to fly this type of fast-rising balloon with a free lift of 2700 grams, which is 1100 grams more than that used to fly an ML-518. Therefore, the total lift required for the balloon described would be 3300 grams greater than that of an ML-518 balloon, or 7000 grams.

The total lift is directly proportional to the volume of gas, and hence the volume of an ML-518 at release can be represented by 3700 K_1, when K_1 is a constant depending on the density of the gas used, converting lift to volume. Assuming the pressure inside a meteorological balloon to be equal to the ambient pressure throughout the flight, then

$$\frac{P_G\ V_G}{T_G} = \frac{P_B\ V_B}{T_B} \qquad (1)$$

where P_G is the ambient pressure at the ground

V_G is the volume of balloon at launch

T_G is the temperature of the gas at launch

P_B is the ambient pressure at burst

V_B is the volume of balloon at burst

T_B is the temperature of the gas at burst

T_G and T_B will show variations from day to day but, in general, these variations will be relatively small and hence it may be assumed that T_G/T_B is a constant. This is, of course, only true providing the altitude at which the balloon bursts is in the range of 60,000 feet to 100,000 feet where the temperature is fairly constant. Equation (1) may, therefore, be rewritten

$$P_G\ V_G = C \cdot P_B V_B \qquad (2)$$

In the case of an ML-518 balloon released at 760 mm pressure and reaching an altitude of 100,000 feet or 8 mm pressure, and having an initial volume of 3700 K_1, the volume at burst is given by

FACTUAL DATA (continued)

TASK B, Phase 6, Part B (continued)

$$V_B = \frac{P_G V_G}{C \cdot P_B} = \frac{760 \cdot 3700 K_1}{C \cdot 8} \tag{3}$$

The streamlined balloon described has initially the same flaccid volume as an ML-518 and will, therefore, burst at the same volume, V_B. However, the initial volume of gas used for this balloon is 7000 K_1. Hence, from equation (2)

$$P_B = \frac{P_G V_G}{C \cdot V_B} = \frac{760 \cdot 7000 K_1}{C \cdot V_B} \tag{4}$$

Substituting for V_B from equation (3)

$$P_B = \frac{760 \cdot 7000 K_1 \cdot C \cdot 8}{C \cdot 760 \cdot 3700 K_1} = 15.1 \text{ mm}$$

This pressure corresponds to an altitude of 86,000 feet. Therefore, a lighter, shorter balloon should be capable of reaching an altitude of 75,000 feet.

A reduction in the weight of this balloon by 800 grams would result in an assembly weight of 2200 grams and a total lift of 6200 grams. In order to retain the same wall thickness, it would be necessary to reduce the length of the balloon. The weight of the balloon proper has been reduced from 2400 grams to 1600 grams, and the weight is proportional to the area of the balloon film which is proportional to the square of the length. Therefore, if L_2 is the new length

$$L_2^2 = \frac{1600}{2400} (100'')^2 \quad \text{and } L_2 = 81.6 \text{ inches}$$

The volume at burst of a 100-inch balloon is given by

$$V_B = \frac{760 \cdot 3700 K_1}{C \cdot 8} \quad \text{(equation 3)}$$

Hence, the volume of a balloon 81.5 inches long is given by

$$V_B \; 81.5 = \frac{760 \cdot 3700 K_1}{C \cdot 8} \left(\frac{81.5^3}{100^3}\right)$$

FACTUAL DATA (continued)

TASK B, Phase 6, Part B (continued)

Therefore, from equation (4) the pressure at burst of such a balloon flown with a total lift of 6200 grams is given by

$$P_B\ 8.15 = \frac{760 \cdot 6200\ K_1}{C} \times \frac{C \cdot 8}{760 \cdot 3700\ K_1} \times \frac{100^3}{81.5^3} = 24.9 \text{ mm}$$

This corresponds to an altitude of 76,000 feet.

Therefore, a balloon assembly weighing 2200 grams of which 600 grams constitutes a streamlined tail assembly and having a flaccid length of approximately 80 inches should reach an altitude of 75,000 feet when flown with a total lift of 6200 grams.

The above figures are based on the performance of a day-flight balloon. In order to achieve the same results at night, the performance of an ML-537 can be taken as a basis. This balloon may be considered as weighing 1000 grams and having a flaccid length of 110 inches.

The corresponding fast-rising balloon would, therefore, weigh 3000 grams and would carry a tail weighing 750 grams. Such an assembly flown with a free lift of 2700 grams and carrying a standard radiosonde would have a total lift of 7750 grams, compared with 3900 grams total lift for an ML-537.

Substituting in equation (3)

$$V_B = \frac{760 \cdot 3900\ K_1}{C \cdot 8}$$

Therefore,

$$P_B = \frac{760 \cdot 7750\ K_1 \cdot C \cdot 8}{C \cdot 760 \cdot 3900\ K_1} = 16.3 \text{ mm}$$

This corresponds to an altitude of 85,000 feet.

A similar reduction in weight as was described for the day-flight balloon would reduce the weight of the balloon proper to 2000 grams, and in order to maintain the wall thickness, the length would have to be reduced to

$$L_3 \text{ where } L_3^2 = \frac{2000}{3000}(110)^2 \quad \text{and} \quad L_3 = 89.8$$

TASK B, Phase 6, Part B (continued)

Following the same reasoning as for the day-flight balloon

$$V_B\ 89.8 = \frac{760 \cdot 3900\ K_1}{C \cdot 8} \left(\frac{89.8^3}{110^3}\right)$$

Therefore,

$$P_B\ 89.8 = \frac{760 \cdot 6750\ K_1}{C} \times \frac{C \cdot 8}{760 \cdot 3900\ K_1} \times \frac{100^3}{89.8^3} = 19.2 \text{ mm}$$

This corresponds to an altitude of 81,000 feet.

Therefore, a balloon assembly weighing approximately 2800 grams, of which 750 grams constitutes a tail assembly, and having a flaccid length of approximately 90 inches, should reach an altitude of at least 75,000 feet when flown with a total lift of 6750 grams.

The figures thus determined are very close to those specified for the ML-541 balloon which is required to reach 75,000 feet in the daytime, and for the ML-550 balloon which is required to reach this altitude at night. It appears, therefore, that the basis of calculation is quite sound.

In the case of a balloon designed to reach altitudes of 100,000 feet at 1700 feet per minute, the ML-564 may be taken as a basis for calculation. This is a dual-purpose balloon, but experience has indicated that a day-flight balloon weighing 1500 grams and having a flaccid length of 140 inches will reach an altitude of 120,000 feet.

Hence, if the wall thickness is tripled and a tail consisting of a thin-walled ML-564 type with the top cut away and weighing 1100 grams is attached, an assembly weighing 5600 grams will be obtained. Such a balloon flown with a free lift of 3000 grams would require a total lift of 9900 grams. This compares with a total lift of 4400 grams for a 1500-gram balloon.

Following the same reasoning as previously, from equation (3)

$$V_B\ 564(\text{day}) = \frac{760 \cdot 4400\ K_1}{C \cdot 3.24}$$

and substituting the appropriate values in equation (4)

$$P_B = \frac{760 \cdot 9900\ K_1 \cdot C \cdot 3.24}{C \cdot 760 \cdot 4400\ K_1} = 7.3 \text{ mm}$$

TASK B, Phase 6, Part B (continued)

This corresponds to an altitude of 102,000 feet.

Hence, a day-flight, fast-rising balloon required to reach an altitude of 100,000 feet should have an assembly weight of 5600 grams and a flaccid length excluding the tail of 140 inches.

The standard ML-564 balloon designed to fly at night weighs 1800 grams and has a flaccid length of 150 inches. Therefore, the thick-walled balloon would weigh 5400 grams, and with the tail assembly it would weigh 6750 grams. Such a balloon would require a total lift of 11,000 grams, as compared with a total lift for the ML-564 of 4700 grams.

Therefore,

$$V_{B\ 564} = \frac{760 \cdot 4700\ K_1}{C \cdot 3.24}$$

and

$$P_B = \frac{760 \cdot 11{,}000 \cdot C \cdot 3.24}{C \cdot 760 \cdot 4700\ K_1} = 7.6 \text{ mm}$$

This corresponds to an altitude of 101,000 feet.

Summarizing the above results and also determining the length of the total balloon assembly, the following physical characteristics are obtained for the four required balloons:

Altitude (feet)	Day/Night Flight	Weight (grams)		Length (inches)	
		Balloon	Assembly	Balloon	Assembly
75,000	Day	1600	2200	80	135
75,000	Night	2000	2800	90	150
100,000	Day	4500	5600	140	205
100,000	Night	5400	6750	150	220

Part C: Determination of Physical Properties of Constant-Level Balloon Films

Under normal applications, a neoprene balloon which has been inflated to have positive bouyancy when launched will rise in the atmosphere and expand as it rises. This will continue until the internal pressure causes the ultimate elongation of the neoprene film to be exceeded at some point on its surface. At this point, the balloon is ruptured.

On the other hand, if the modulus of the neoprene is such that the tension in the balloon increases rapidly as the balloon expands, it is entirely possible for the situation to develop in which the increased tension prevents further expansion of the balloon. The balloon will then float at this level of zero bouyancy.

This condition of zero bouyancy is determined by the interaction of several factors involving characteristics of the neoprene film and the decrease of pressure with altitude in the atmosphere. These will be discussed separately in turn.

1. Modulus of Neoprene Film

On the basis of empirical data presented by us in 1958 (see Final Report of Contract No. DA-36-039-SC-72386, Task A, Phase 3, Parts A and B), the modulus of neoprene balloon film may be expressed approximately by the following relationship:

$$m = a \cdot \exp\left(b\frac{E}{100} - c\frac{100}{E} + dT_b\right)$$

where m is modulus in psi

a, b, c, d are constants depending on the sample of neoprene

E is elongation in per cent

T_b is the temperature of the balloon film

In practice, curves have been drawn for various samples of neoprene under many conditions of elongation and temperature. From these data the constants may be evaluated. Further, if one directs attention to elongations greater than 200% or 300%, the term involving E in the denominator of the exponential may be omitted.

Also, considering the temperature to be constant during the stretching of the neoprene, the modulus becomes, approximately:

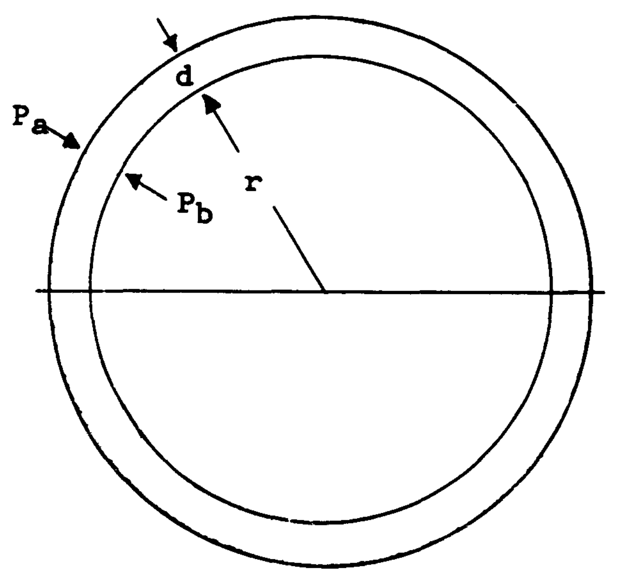
$$m = a \cdot \exp\left(b\frac{E}{100} + c\right) \tag{1}$$

2. Balloon Tension

It is possible to write an expression relating the tension in the balloon film to the elongation, internal pressure, and ambient air pressure. Consider the balloon to be spherical, the balloon film to have uniform thickness, and the internal pressure to be uniform.

In this development these assumptions are not too serious as the percental deviation of the actual conditions from these idealized ones is not great. However, in a later discussion on the location of the most probable point of rupture of the balloon, it will be shown that the deviation of the shape from spherical and the variation of thickness play an important role in determining where the balloon will burst.

If one were to consider the balloon to be divided into hemispheres, the force tending to separate the two halves is:



$$F_s = (P_b - P_a)A = P_d \pi r^2$$

where

F_s is the force separating the two halves

P_b is internal gas pressure

P_a is ambient air pressure

P_d is $P_b - P_a$

A is the cross section area of the balloon

r is the radius of the balloon

The tension in the balloon film holding the two hemispheres together is the same as F_s and may be expressed in terms of the modulus as

$$m = \frac{F_s}{A} = \frac{F_s}{2\pi rd}$$

where d is the thickness of the film.

On combining these two expressions,

$$m = \frac{P_d \cdot r}{2d}$$

But r and d may be expressed in terms of elongation and the flaccid conditions of the balloon. Since the volume of the neoprene is conserved as the balloon expands

$$4\pi r^2 d = \text{constant}$$

is a close approximation to the volume of the neoprene. This may be written in terms of elongation and flaccid conditions as

$$r = \left(\frac{E + 100}{100}\right) \cdot r_f$$

and

$$r_f^{\,2} \cdot d_f = r \cdot d$$

where r_f and d_f are the flaccid radius and thickness, respectively. Then

$$m = \frac{P_d\left(\frac{E + 100}{100}\right)^3 r_f}{2\ d_f} \qquad (2)$$

3. Internal Balloon Pressure

The pressure of the gas inside the balloon is equal to the sum of the ambient air pressure and the pressure difference due to the tension in the balloon film. This may be expressed as

$$P_b = P_a + P_d \qquad (3)$$

FACTUAL DATA (continued)

TASK B, Phase 6, Part C (continued)

Since the gas inside the balloon behaves essentially as an ideal gas, the pressure P_b may be expressed in terms of the elongation and initial pressure by means of the gas law.

$$P_b = \frac{P_o \; T \; (E_o + 100)^3}{T_o \; (E + 100)^3} \tag{4}$$

where P_o is the balloon pressure at the ground when inflated to the desired free lift

T_o is the gas temperature at the ground in ^oK

T is the gas temperature when elongation is E also in ^oK

E_o is initial elongation at the ground

E is elongation at the level in question

4. Balloon Bouyancy

The net bouyancy of the balloon is just the difference between the weight of the balloon (neoprene, gas, and load) and the weight of the volume of air displaced. That is

$$B = \frac{4}{3}\pi\left(\frac{E+100}{100}\right)^3 r_f{}^3 \rho_a g - \frac{4}{3}\pi\left(\frac{E+100}{100}\right)^3 r_f \rho_g g - (M_b+M_R)g \tag{5}$$

where B is the net bouyant force

ρ_a is the ambient air density

ρ_g is the balloon gas density

M_b is the mass of neoprene balloon film

M_R is the mass of load carried by the balloon

g is acceleration of gravity

5. Ambient Air Density

The ambient air density that appears in the equation above and P_a are independent parameters which depend upon the environment only. Consequently, these data must be supplied by the atmosphere or approximated by some set of standard conditions.

FACTUAL DATA (continued)

TASK B, Phase 6, Part C (continued)

6. The determination of conditions for zero bouyancy

It is possible through the use of equations (1) through (5) to derive the conditions under which zero bouyancy will be encountered. If one has the curve of modulus vs. elongation and temperature for a given neoprene compound, the flaccid and initial characteristics of the balloon, and the ambient pressure-temperature-height curve for the atmosphere, these five simultaneous equations may be solved to yield the level of zero bouyancy. Conversely, if the elevation (or pressure) of zero bouyancy is given, the desired modulus-elongation relation may be determined.

One method for the solution of this problem is indicated by the following illustration:

It is required that a Kaysam 8DS (800-gram) balloon float at an elevation of approximately the elevation of 10 mb. What must the modulus be in order to provide zero bouyancy at this elevation?

The balloon constants for this flight are:

M_b = 800 grams	$d_f = 3 \times 10^{-3}$ inches	$T_o = 273^oK$
M_R = 1250 grams	r_f = 30 inches	P_a = 10 mb.
P_{ao} = 1000 mb.	r_o = 35.4 inches	$T = 223^oK$

1) Find E_o

$$\frac{r_o}{r_f} = 1.18; \quad E_o = 18\%$$

2) P_d at the ground, assuming modulus for E = 18 is 100 psi

use equation (2)

$$P_d = \frac{2m\, d_f}{(E+100)^3 r_f} = \frac{2 \times 100 \times 3 \times 10^{-3}}{(1.18)^3 \times 30} = 12.2 \times 10^{-3} \text{ psi}$$

3) Find P_{bo}

use equation (3)

$$P_{bo} = P_{ao} + P_{do} = 14.7 + .012 = 14.712 \text{ psi or } 1000 \text{ mb.}$$

4) The determination of E at the 10 mb. level:

At this elevation, since the balloon is to float, B = 0. One may now use equation (5) to determine the radius of the balloon. To do this, it is first necessary to determine the mass of the hydrogen in the balloon. This may be determined from the size of the balloon and the internal pressure at the ground. From the gas law:

$$\rho_g = \frac{p}{RT} \quad \text{or} \quad M_g = \frac{Vp}{RT}$$

where $V = 109\ ft^3 = 3.08\ m^3$

$p = 1000$ mb.

$R = 4.157 \times 10^7$

$T = 273$

$$M = \frac{3.09 \times 10^6 \times 10^6}{4.157 \times 10^7 \times 2.73 \times 10^2} = 271 \text{ gm}$$

Now, using equation (5)

$$\frac{4}{3}\pi r^3 \rho_a g = (800 + 271 + 1250)g = 2321\ g$$

But at 10 mb, $T = 223^o$

$$\rho_a = \frac{10^6}{2.87 \times 10^6 \times 2.23 \times 10^2} = 1.56 \times 10^{-5} \text{ gm cm}^{-3}$$

Therefore,

$$r^3 = \frac{2321 \times 3}{4\pi \times 1.56 \times 10^{-5}} = 3.55 \times 10^7 \text{ cm}^3$$

$r = 328$ cm = 129 inches

and since $r_f = 30$ inches

$$\frac{r}{r_f} = \frac{129}{30} = 4.3 \qquad \text{and } E = 330\%$$

FACTUAL DATA (continued)

TASK B, Phase 6, Part C (continued)

5) The determination of P_d at 10 mb.

using equation (4)

$$P_b = 10^3 \times \frac{223}{273} \times \frac{(1.18)^3}{(4.3)^3} \times 16.9 \text{ mb.}$$

and by equation (3)

$$P_d = 16.9 - 10 = 6.9 \text{ mb} = .102 \text{ psi}$$

6) The determination of the modulus at 10 mb:

The modulus required for an elongation of 330% to produce this pressure difference of .102 psi may be determined by using equation (2)

$$m = \frac{.102 \times (4.3)^3}{2} \times \frac{30}{3 \times 10^{-3}} = 4.04 \times 10^4 \text{ psi}$$

This corresponds to about 9400 psi as determined in the dumbbell test.

Part D: Analysis of Stress in Sounding Balloons

It is apparent that in order to predict the behavior of a balloon as it expands in flight, it is necessary to have an understanding of the stresses generated in the balloon film as it rises in the atmosphere. These stresses may be characterized as mechanical and thermal. The thermal properties (including radiation) of the atmospheric environment and of the balloon have been discussed in part in Report No. 4, Task B, Phase 3. This section will deal with an analysis of what happens mechanically as the balloon expands and bursts.

As a first approach to the stress problem, one may investigate the most likely point of rupture on the balloon surface as the balloon expands to its ultimate elongation. If it is found to clearly be at one consistent portion of the surface of the balloon, the opportunity then affords itself to strengthen the balloon at that location and consequently improve its performance.

Visual observations of radiosonde balloons in flight indicate that the balloon assumes a nearly spherical shape as it approaches its ultimate elongation. However, it is impossible to see where the first rupture occurs. The balloon seems to shatter all over at the same time.

Consider the balloon to be a sphere of uniform thickness with the radiosonde weight suspended from a point at the lower (south) pole of the sphere. Further, if the balloon is to maintain its lift up to the bursting level, it is necessary that the modulus of the neoprene be small enough at the elongations encountered so that the balloon is essentially free to expand even at extreme altitudes.

In this connection, the report dealing with neoprene constant pressure-altitude balloons (see Task B, Phase 6, Part C) indicates that this is a necessary condition. Otherwise, the balloon will stop expanding and will tend to find some level of equilibrium at which it will float. This condition implies that for a freely rising balloon, the pressure difference between the internal gas and the ambient air must be near zero.

Under these conditions, the forces acting on the balloon film are bouyancy, the weight of the neoprene, the tension due to the elongation of the neoprene, and the weight of the radiosonde instrument. If the balloon were perfectly spherical and homogeneous, then the only force applied at a single point and consequently capable of exerting the maximum tension on the balloon film would be the radiosonde weight. Since the balloon surface is horizontal at this point, the tension required to support the weight of the radiosonde would become infinitely great. The south pole of the balloon would then be the weakest point on the surface of the balloon.

In practice, however, the balloon is not perfectly spherical. Nor is it exactly uniform in thickness or composition. This is immediately apparent as one observes the distortions in a balloon as it is being inflated. The shape of the balloon becomes somewhat like an inverted teardrop. The cone of the neck tapers down to nearly a cylinder where the radiosonde is attached. The force of bouyancy also stretches the top so that the vertical dimension of the balloon is much larger than the horizontal. The fact that the neck of the balloon is elongated reduces the tension in the film at that point and permits the weight to be supported.

In view of these actual distortions of the balloon shape from spherical, it is suggested that a series of experiments be conducted to determine the actual growth shape of the balloon and to determine the breaking characteristics of the balloons. These experiments should simulate flight conditions as closely as possible. This could be

accomplished by inflating a captive balloon to the prescribed bouyancy and then continuing to inflate the balloon with air so that the bouyancy does not change until the balloon bursts.

By observing the location where the balloon bursts, one may find the weakest point on the surface or the point of maximum stress requiring the greatest reinforcement. If this weakest point consistently appears at one preferred location, then this would clearly indicate the part to be strengthened. This procedure would also be desirable in connection with a mathematical analysis of the stresses in that it would provide an objective verification of the theory.

Since the breaking of the balloon occurs in the order of time of a millisecond, ordinary visual observation is inadequate to determine where the break first occurred. To accomplish this, a photographic technique must be used. In this connection, an electronic flash lamp was designed and constructed.

In theory, the operation of the flash is as follows: A sensitive microphone is placed in contact with the neck of the balloon. When the balloon bursts, the shock of the taut neoprene film rupturing is transmitted through the film to the microphone. An electrical signal from the microphone is amplified and transmitted to a special trigger circuit. This impulse is shaped so that the electronic flash lamp may be flashed. The experiment is carried out in darkness so that a camera with its shutter open will record the image of the balloon in the light of the flash lamp.

Figure 4 is a photograph of the electronic components of the equipment used. The microphone is at the lower left in the photograph. This is connected to the amplifier located just above it. The trigger circuit is located just above the amplifier. In the lower right of the photograph is the power supply which generates the 3000 volts DC required to charge the flash capacitor. The capacitor and lamp are above the high voltage power supply. A Polaroid Model 110B camera was used to make the exposures.

Since the time delay of the electronic pulse is of the order of micro-seconds, the longest delay involved is the transmission of the shock wave in the neoprene from the point of rupture to the microphone. To test the capability of this equipment to actually photograph the breaking of the balloon, an exposure was made using a 10-gram balloon inflated with air. The microphone was attached to the neck of the balloon, and the film was ruptured by burning its surface. The result of this experiment is indicated in Figure 5.

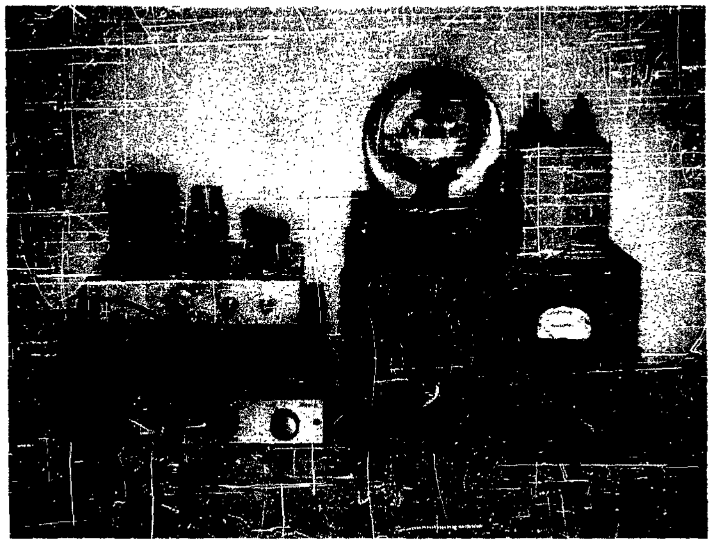


FIGURE 4

EQUIPMENT USED IN PHOTOGRAPHING BALLOONS AT BURST

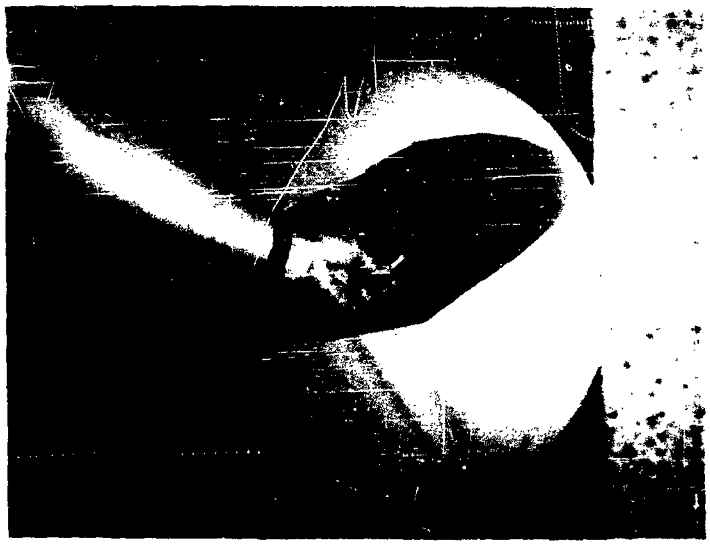


FIGURE 5

DEMONSTRATION OF OPERATION OF EQUIPMENT

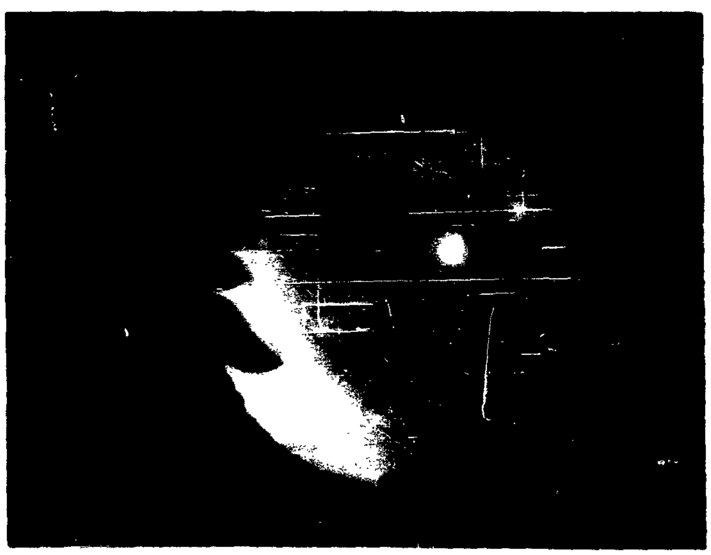


FIGURE 6

BURSTING PATTERN OF 30-GRAM BALLOON INFLATED WITH HELIUM

FACTUAL DATA (continued)

TASK B, Phase 6, Part D (continued)

It is evident from this figure that it is possible to photograph the breaking of a balloon soon enough after the break has occurred so that the location of the break can be recorded.

Another experiment in which a 30-gram balloon was inflated with helium until it burst spontaneously is shown in Figure 6. This illustrates that the break occurred near the equator of the balloon. Further experiments in which the radiosonde balloon is more closely modelled will be carried out. In addition to the bursting of balloons, photographs of the shape of the balloon during inflation will be made to be used in connection with the mathematical analysis of the stresses in the balloon surface.

TASK C: STUDY OF BALLOON CONFIGURATION

Phase 1: Design and Construction of Equipment

No progress during this period.

Phase 2: Construction of One-Piece Balloons for Flight Testing

No progress during this period.

Phase 3: Construction of Balloons having Mechanical Attachments to Improve Rate of Ascent

The physical properties of compound A3-134 suggest that it should be suitable for use in fast-rising balloons. Accordingly, thick-walled balloons were manufactured from this compound.

At the same time, three thick-walled balloons were also manufactured from compound A3-102. This is a sulphur-bearing compound, and some good flights had previously been obtained with balloons made from it. However, experience has shown that the life of this compound in a dipping tank is limited, a condition similar to that of pre-cure in a natural latex compound developing upon storage for two or three months. It would seem that cross-linking occurs in the latex phase due to the presence of the sulphur; and if good performance can be obtained with balloons made from compound A3-134, this problem would be eliminated.

On all of these balloons a tail, consisting of approximately four-fifths of a thin-walled, 1000-gram balloon made from compound A3-106, was affixed at a circle approximately 18 inches below the equator of the thick-walled balloon.

FACTUAL DATA (continued)

TASK C, Phase 3 (continued)

The balloons made from compound A3-102 were identified as EX-2C-1151 through EX-2C-1153. The balloons made from compound A3-134 were identified as EX-2C-1161 through EX-2C-1167 and EX-2C-1171 through EX-2C-1176. Seven of these balloons were post-plasticized, six of which were flown at night and one during the day. The post-plasticized balloons are EX-2C-1165 through EX-2C-1167, EX-2C-1171, EX-2C-1172, EX-2C-1174, and EX-2C-1176.

All of these balloons were flown with a free lift of 2700 grams. Their characteristics and flight performance are given in Table 14.

In order to evaluate the performance of these balloons more realistically, the rate of ascent over 10,000-foot intervals was calculated as well as the temperature at each 10,000-foot level. The results of these calculations are given in Tables 15 through 17. It was possible to perform these calculations only for balloons EX-2C-1151 through EX-2C-1153 and EX-2C-1161 through EX-2C-1167, the remaining balloons having been flown too late in the quarter.

An examination of these flight data shows that in every case the balloon accelerates until about the middle altitude attained and then gradually decelerates for the remainder of the flight. Balloons EX-2C-1151 and EX-2C-1152 show curiously large accelerations in the last stages of the flight, but it is felt that these figures should be regarded with suspicion. This behavior is usual for this type of balloon and, in part, is certainly due to the fact that as the balloon expands the tail is drawn up around the lower part of the balloon thus destroying the streamlined shape. This will tend to reduce the rate of ascent of the balloon, but it is more than offset during the early part of the flight by the reduction in atmospheric density and, therefore, the viscosity.

A closer examination of the flights of balloons EX-2C-1151, EX-2C-1152, and EX-2C-1153, however, reveals another point. Balloon EX-2C-1151 was the lightest and longest balloon and, therefore, had the lowest wall thickness. Nevertheless, it achieved the highest rate of ascent, and furthermore, the minimum temperature encountered was the highest of the three flights. Balloon EX-2C-1153 had the greatest wall thickness, encountered the lowest temperature, and was the slowest of the three balloons.

Of the four balloons, EX-2C-1161 through EX-2C-1164, the latter encountered the lowest temperature and was the slowest balloon. It also had a relatively high wall thickness. Balloons EX-2C-1161 and EX-2C-1162 had lower wall thicknesses than either of the other two and were both faster than EX-2C-1164.

FACTUAL DATA (continued)

TASK C, Phase 3 (continued)

TABLE 14

FLIGHT RESULTS - STREAMLINED BALLOONS MADE FROM COMPOUNDS A3-102 AND A3-134

Experiment No.	Balloon No.	D or N	Balloon Weight (grams)	Balloon Length (inches)	Assembly Weight (grams)	Assembly Length (inches)	Altitude at Burst (feet)	Ascensional Rate (feet/min.)
				Compound A3-102				
EX-2C-1151	M18-1AM	D	1765	111	2700	158	94,600	1736
EX-2C-1152	M18-2AM	D	2290	106	3205	155	102,600	1667
EX-2C-1153	M18-3AM	D	2410	106	3405	159	97,960	1523
				Compound A3-134				
EX-2C-1161	S14-3AM	D	1815	105	2820	156	94,000	1646
EX-2C-1162	S14-4AM	D	2145	103	3220	159	80,500	1779
EX-2C-1163	S14-5AM	D	2085	94	3065	147	91,300	1718
EX-2C-1164	S14-6AM	D	2070	97	3070	156	92,400	1406
EX-2C-1165	S14-7AM	N	2320	115	3320	159	90,960	1448
EX-2C-1166	S15-5AM	N	2425	99	3390	149	68,100	1357
EX-2C-1167	S15-6AM	N	2340	103	3200	147	83,000	1584
EX-2C-1171	T2-3TK	N	1850	98	2845	156	85,900	1576
EX-2C-1172	T3-2TK	N	1780	101	2790	155	88,400	1506
EX-2C-1173	T3-4TK	D	1515	89	2470	152	89,590	1566
EX-2C-1174	T3-5TK	D	1825	87	2830	150	77,140	1819
EX-2C-1175	T4-2TK	D	1580	89	2710	157	88,100	1653
EX-2C-1176	T4-3TK	N	1915	99	2850	150	93,400	1578

TABLE 15

FLIGHT ANALYSIS - BALLOONS EX-2C-1151 THROUGH EX-2C-1153

Altitude Interval (feet)	EX-2C-1151		EX-2C-1152		EX-2C-1153	
	Temp. (°C)	Ascent (ft/min)	Temp. (°C)	Ascent (ft/min)	Temp. (°C)	Ascent (ft/min)
0 - 10,000	29.0	1358	29.0	1467	30.0	1608
10,000 - 20,000	10.0	1736	6.0	1704	7.5	1694
20,000 - 30,000	- 4.5	1825	-10.5	1952	- 7.5	2012
30,000 - 40,000	-28.0	2000	-33.5	2024	-27.5	1821
40,000 - 50,000	-55.0	2486	-58.5	1594	-52.5	1542
50,000 - 60,000	-66.0	1982	-68.0	1755	-73.0	2191
60,000 - 70,000	-58.5	2000	-	2052	-63.5	1120
70,000 - 80,000	-54.0	1727	-	1116	-54.5	1218
80,000 - 90,000	-44.5	1317	-	1072	-48.5	1571
90,000 - 100,000	-42.5	2294	-48.5	3155 ?	-42.0	1106
Temp. at Burst	-38.5		-41.5		-41.0	
Average Rate of Ascent		1736		1667		1523

FACTUAL DATA (continued)

TASK C, Phase 3 (continued)

TABLE 16

FLIGHT ANALYSIS - BALLOONS EX-2C-1161 THROUGH EX-2C-1164

Altitude Interval (feet)	EX-2C-1161		EX-2C-1162		EX-2C-1163		EX-2C-1164	
	Temp. (°C)	Ascent (ft/min)	Temp. (°C)	Ascent (ft/min)	Temp. (°C)	Ascent (ft/min)	Temp. (°C)	Ascent (ft/min)
0- 10,000	26.5	1400	29.0	1430	24.0	1308	25.5	1177
10,000- 20,000	8.5	1559	6.5	1807	3.0	2312	6.5	1285
20,000- 30,000	- 7.0	1781	- 8.5	2089	- 9.0	2125	- 8.5	1397
30,000- 40,000	-30.5	2047	-34.0	2382	-32.0	1833	-30.5	1426
40,000- 50,000	-49.0	2212	-52.0	2315	-50.0	1553	-56.5	1561
50,000- 60,000	-67.5	1814	-63.5	1793	-56.5	1789	-68.0	1645
60,000- 70,000	-64.0	1711	-65.0	1677	-65.5	1854	-60.5	1677
70,000- 80,000	-59.0	1636	-58.0	1324	-59.5	1672	-56.5	1469
80,000- 90,000	-49.0	1216	-49.5	-	-49.5	1520	-48.5	1196
90,000-100,000	-42.0	1320						
Temp. at Burst	-43.6		-49.5		-45.0		-43.0	
Average Rate of Ascent		1646		1779		1718		1406

TABLE 17

FLIGHT ANALYSIS - BALLOONS EX-2C-1165 THROUGH EX-2C-1167

Altitude Interval (feet)	EX-2C-1165		EX-2C-1166		EX-2C-1167	
	Temp. (°C)	Ascent (ft/min)	Temp. (°C)	Ascent (ft/min)	Temp. (°C)	Ascent (ft/min)
0 - 10,000	27.0	1446	28.0	1202	28.5	1494
10,000 - 20,000	5.5	1272	5.5	1406	9.0	1743
20,000 - 30,000	-14.0	1486	-10.5	1414	- 8.0	1829
30,000 - 40,000	-38.0	2362	-31.5	1539	-28.5	1828
40,000 - 50,000	-55.5	2291	-56.5	1500	-54.0	1782
50,000 - 60,000	-65.0	1701	-72.0	1380	-66.5	1508
60,000 - 70,000	-59.5	1210	-62.0	1137	-64.0	1522
70,000 - 80,000	-54.5	1247			-56.0	1244
80,000 - 90,000	-52.0	987			-50.0	1296
Temp. at Burst	-46.5		-57.0		-51.0	
Average Rate of Ascent		1448		1357		1584

TASK C, Phase 3 (continued)

The minimum temperatures encountered by EX-2C-1161 and EX-2C-1162 were also higher than that encountered by EX-2C-1164. Balloon EX-2C-1163 encountered about the same minimum temperature as did EX-2C-1162 but had a greater wall thickness and was somewhat slower.

The internal pressure developed in a balloon depends on the modulus of the film and the wall thickness. For a given compound, the modulus increases as the temperature decreases. Now, an increase in internal pressure will have the effect of increasing the density of the lifting gas, thereby reducing the total lift. The fact that all the night flights were slower than the day flights (the exception being EX-2C-1164) and that the balloon is much colder and therefore liable to have a much higher modulus, even though post-plasticized, suggest that compounds A3-102 and A3-134 have too high a modulus.

The rate of ascent attained with balloon EX-2C-1174 which was post-plasticized and flown in the daytime and which gave the highest rate of ascent of any of the last group of flights tends to confirm this. Additional balloons made in this manner will be submitted for flight.

The altitudes attained by these balloons agree rather well with the forecast of the theoretical study presented in Task B, Phase 6 of this report, and larger balloons will now be made in order to confirm the theory at the higher altitudes.

Phase 4: Construction of Balloons having Selective Compound Modulation

No progress during this period.

TASK D: FIELD EQUIPMENT FOR PRECONDITIONING BALLOONS

No progress during this period.

CONCLUSIONS

TASK A: STUDY OF BALLOON FILMS AND THEIR EFFECT ON BALLOON FLIGHT PERFORMANCE

Phase 1: Study of the Literature

Nothing of interest was revealed by the study of the literature during this period.

Phase 2: Study of Raw Materials

Part A: Neoprene Polymers

Samples of three new types of neoprene latex were received, and work was begun on their investigation; however, there are no results to report as yet.

A study of the effect of maturing neoprene latex and neoprene compounds indicates that greater uniformity of cured physicals may be obtained by such means. Work on this study will continue.

Part B: Plasticizers

No progress during this period.

Part C: Antioxidants and Antiozonants

No progress during this period.

Part D: Accelerators

It was shown that variation of the amount of Merac in a balloon compound has little effect on the room-temperature physical properties but that increased quantities of Merac seem to improve elongation and decrease modulus at -40°C.

Increasing the amount of Accelerator 833 in a balloon compound results in a considerable increase in room-temperature elongation which is accompanied by a substantial drop in modulus. This is also true at -40°C. The increase in low-temperature elongation suggests that this phenomenon may be of use in increasing the bursting altitude of balloons.

Part E: Polymers other than Neoprene

No progress during this period.

CONCLUSIONS (continued)

TASK A, Phase 2 (continued)

Part F: Reinforcing Fillers

It was shown that the modulus of a balloon film can be raised by incorporation of Mistron Vapor in the compound. At room temperature, the tensile strength is also increased and there is relatively little change in elongation. At -40°C there is a slight increase in the modulus at 200%, but practically no change in the modulus at 400% and 600% or in the tensile strength and elongation. It would appear, therefore, that Mistron Vapor could be used to advantage in fast-rising balloon compounds.

The possibilities of using zinc resinate instead of zinc oxide were investigated, but the problems more than offset the theoretical advantages, and this project was abandoned.

Phase 3: Development of Formulations with Desirable Film Properties

Part A: High-Altitude Balloon Compounds

No progress during this period.

Part B: Dual-Purpose Balloon Compounds

Compounds were designed containing Merac and a combination of Merac and Accelerator 833, and they were shown to have satisfactory physical properties at both room- and low-temperatures. There was, however, no indication that these compounds were inherently superior to A3-106.

A compound containing Neoprene 400 and Dibutyl Sebacate which had satisfactory physical properties proved to be too soft to handle in the gel stage.

A compound containing Neoprene 571 as the modulus-increasing polymer and Dibutyl Sebacate as the plasticizer froze at -70°C, whereas compounds containing the same quantity of Butyl Oleate do not.

A dual-purpose compound containing Mistron Vapor was designed and shown to have satisfactory physical properties at room temperature and at -70°C.

Part C: Fast-Rise Balloon Compounds

Another compound containing Mistron Vapor was designed for use in fast-rising balloons. This was a day-flight compound with a very high modulus, high tensile strength, and very good elongation at both room temperature and at -40°C. After post-plasticizing, this compound appeared to have excellent physical properties for night-time, fast-rising balloons.

CONCLUSIONS (continued)

TASK A (continued)

Phase 4: Correlation of Film Properties with Flight Data

Part A: High-Altitude Balloons

No progress during this period.

Part B: Dual-Purpose Balloons

Further flights were conducted with 1000-gram balloons made from compound A3-106. It was shown that variations from the normal balloon, either in curing conditions or wall thickness, did not improve the flight performance. Balloons which had been subjected to accelerated heat aging were shown to perform as well as freshly-made balloons.

Flights with balloons made from compounds containing Merac (A3-132 and A3-136) showed them to be equal to compound A3-106, and better rates of ascent were obtained with balloons made from compound A3-135 which contains a combination of Merac and Accelerator 833.

Additional balloons made from compound A3-129 were flown, and its performance at the 100,000-foot level was confirmed.

Balloons made from compound A3-133 which gives a very soft gel which is difficult to handle and tends to give thin necks were surprisingly good, but the compound cannot be considered suitable from a production standpoint.

Balloons made from compound A3-137 which contains Mistron Vapor performed well and had a very good ascensional rate which was anticipated.

Part C: Fast-Rise Balloons

No progress during this period.

TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON FILM PERFORMANCE

Phase 1: Effect of Pre-elongation

No progress during this period.

Phase 2: Effect of Ozone

No progress during this period.

CONCLUSIONS (continued)

TASK B (continued)

Phase 3: Effect of Infra-Red Radiation

Determination of the spectral characteristics of red, white, and black neoprene films showed that in all essentials, characteristics of the red and white films are the same. However, black neoprene shows considerably less transmissivity and considerably greater reflectivity. The absorptivity is consistently and substantially greater for black as compared to white or red films.

Phase 4: Effect of Ultra-Violet and other Short-Wave Radiation

Irradiation of balloon films with ultra-violet light from a single 2800 A° bulb has no effect on the physical properties.

Phase 5: Correlation of Physical Properties with Flight Performance

No progress during this period.

Phase 6: Prediction of Balloon Performance

Part A: Determination of Burst Altitude from Residual Elongation

No progress during this period.

Part B: Determination of Dimensions of Fast-Rising Balloons

A theoretical determination of the dimensions of fast-rising balloons was made using the performance of ML-518 and ML-564 balloons as a basis. It was shown that the dimensions of the ML-541 and ML-550 balloons can be determined in this manner, and the dimensions necessary for 100,000-foot, fast-rising balloons for both day and night flights were also calculated.

Part C: Determination of Physical Properties of Constant-Level Balloon Films

It was shown that in order to make an expanding balloon float at a fixed altitude, a tensile strength of approximately 10,000 pounds per square inch is necessary. This tensile strength is the figure obtained by dumbbell testing, and it actually represents a much higher stress in the expanded film. It would, therefore, be necessary to design a compound having such a tensile strength at -40°C and -70°C to be able to produce super-pressure, constant-level, expandable balloons.

CONCLUSIONS (continued)

TASK B, Phase 6 (continued)

Part D: Analysis of Stress in Sounding Balloons

A theoretical study of the stresses in a balloon indicate that burst should occur close to the neck, this being the area of maximum stress. However, due to deformation of the balloon in flight by the action and reaction of the lifting gas and payload, this is not necessarily the case. The equipment designed to photograph a balloon at burst was operated successfully and proved to be reliable.

TASK C: STUDY OF BALLOON CONFIGURATION

Phase 1: Design and Construction of Equipment

No progress during this period.

Phase 2: Construction of One-Piece Balloons for Flight Testing

No progress during this period.

Phase 3: Construction of Balloons having Mechanical Attachments to Improve Rate of Ascent

Fast-rise balloons with streamlined tails were made from compound A3-102 and A3-134 which contains Mistron Vapor. The balloons, in general, reached the predicted altitudes, and fairly good rates of ascent ranging from 1600 feet per minute to 1700 feet per minute were obtained in the daytime. The rate of ascent at night was less satisfactory, being about 100 feet per minute less than the day-flight balloons.

There are indications that the modulus of the compound may be greater than is desirable, and this may be reducing the rate of ascent to below the desired level.

Phase 4: Construction of Balloons having Selective Compound Modulation

No progress during this period.

TASK D: FIELD EQUIPMENT FOR PRECONDITIONING BALLOONS

No progress during this period.

PROGRAM FOR THE NEXT INTERVAL

TASK A: STUDY OF BALLOON FILMS AND THEIR EFFECT ON BALLOON FLIGHT PERFORMANCE

Phase 1: Study of the Literature

The study of the literature will be continued throughout the next period.

Phase 2: Study of Raw Materials

Part A: Neoprene Polymers

The evaluation of the three neoprene polymers received during the last quarter will be completed.

Part B: Plasticizers

No work is planned for this period.

Part C: Antioxidants and Antiozonants

No work is planned for this period.

Part D: Accelerators

Additional work will be done with increased quantities of accelerator in view of the apparent beneficial effect obtained by this means.

Part E: Polymers other than Neoprene

No work is planned for this period.

Part F: Reinforcing Fillers

Additional work will be done with Mistron Vapor to determine the optimum usage of this material.

Phase 3: Development of Formulations with Desirable Film Properties

Part A: High-Altitude Balloon Compounds

High-altitude balloon compounds will be designed incorporating larger quantities of those accelerators which improve elongation in an effort to increase altitudes. In conjunction with this, the use of Mistron Vapor to maintain modulus will also be investigated.

PROGRAM FOR THE NEXT INTERVAL (continued)

TASK A, Phase 3 (continued)

Part B: Dual-Purpose Balloon Compounds

The program described in Part A will also be applied to the design of dual-purpose balloon compounds.

Part C: Fast-Rise Balloon Compounds

Additional compounds will be designed for use in fast-rising balloons, and compounds covering a wide range in modulus at all temperatures will be evaluated.

Phase 4: Correlation of Film Properties with Flight Data

Part A: High-Altitude Balloons

Balloons weighing 1500 grams and more will be manufactured from the compounds designed in Phase 3, Part A; and these will be submitted for flight testing.

Part B: Dual-Purpose Balloons

A program similar to that in Part A will be undertaken for dual-purpose balloons. Only in the case of compounds which show a substantially greater low-temperature elongation will balloons weighing 1000 grams be submitted for testing. Such balloons would be expected to reach higher altitudes than the 100,000 feet which is normal for this type.

Part C: Fast-Rise Balloons

A limited number of one-piece, spherical, fast-rising balloons will be submitted for flight testing.

TASK B: EFFECT OF FLIGHT CONDITIONS ON BALLOON FILM PERFORMANCE

Phase 1: Effect of Pre-elongation

No work is planned for this period.

Phase 2: Effect of Ozone

No work is planned for this period.

Phase 3: Effect of Infra-Red Radiation

No work is planned for this period.

TASK B (continued)

Phase 4: Effect of Ultra-Violet and other Short-Wave Radiation

The determination of the effect of ultra-violet radiation on balloon films will be continued using more intense radiation in the 2800 A° range.

Phase 5: Correlation of Physical Properties with Flight Performance

Flights will be conducted wherever it is necessary to confirm the findings of other phases within this task. In particular, additional flights will be made with white or colored balloons.

Phase 6: Prediction of Balloon Performance

Part A: Determination of Burst Altitude from Residual Elongation

No work is planned for this period.

Part B: Determination of Dimensions of Fast-Rising Balloons

No work is planned for this period.

Part C: Determination of Physical Properties of Constant-Level Balloon Films

No work is planned for this period.

Part D: Analysis of Stress in Sounding Balloons

Additional photography of balloons at burst will be conducted in order to determine the area of initial rupture.

TASK C: STUDY OF BALLOON CONFIGURATION

Phase 1: Design and Construction of Equipment

It is planned to construct one form having two necks in order to produce two-piece balloons which can be more easily handled at inflation. It is also planned to construct one form designed to produce a one-piece balloon which will have initially and maintain upon inflation a teardrop shape.

Phase 2: Construction of One-Piece Balloons for Flight Testing

Balloons will be made on the latter form described in Phase 1 above in order to determine the feasibility of making one-piece, fast-rise balloons.

PROGRAM FOR THE NEXT INTERVAL (continued)

TASK C (continued)

Phase 3: Construction of Balloons having Mechanical Attachments to Improve Rate of Ascent

Additional two-piece, streamlined, fast-rise balloons made from newly-developed compounds will be submitted for flight testing.

Phase 4: Construction of Balloons having Selective Compound Modulation

No work is planned for this period.

TASK D: FIELD EQUIPMENT FOR PRECONDITIONING BALLOONS

No work is planned for this period.

IDENTIFICATION OF KEY TECHNICAL PERSONNEL

Name	Number of Hours
Eric Nelson	210
Martin Krentcil	432
Harding Wing	265
Frederick McWilliams	236

AD________________ Accession No. ________________	Unclassified
Kaysam Corporation of America, Paterson, N. J. Study of Physical and Chemical Characteristics of Balloons and Balloon Materials By Eric Nelson, Herman Newstein & John Kantor Sixth Quarterly Progress Report, Oct. 24, 1961 Pages, 68 - Tables, 17 - Figures, 6 Signal Corps Contract No. DA-36-039-SC-84925 Dept. of the Army Project No. 3D36-21-001-04 Unclassified Report Progress is reported on work accomplished in connection with the following tasks: TASK A - STUDY OF BALLOON FILMS AND THEIR EFFECT ON BALLOON FLIGHT PERFORMANCE. An evaluation of three new neoprene polymers was begun, and the study of the behavior of aged neoprene latex was continued. Increasing the quantity of two accelerators increased elongation at +20°C and -40°C. Mistron Vapor was shown to increase modulus and tensile without reducing elongation. The use of zinc resinate was investigated and discarded. Compounds containing a Merac/Accelerator 833 blend were satisfactory. The use of Dibutyl Sebacate only in dual-purpose compounds gave unsatisfactory low-temperature elongation and gels which are too soft to handle. High-modulus compounds containing Mistron Vapor are generally satisfactory. Flights conducted with balloons made from compounds containing Merac (A3-132,A3-135 and A3-136), and Butoxy Ethyl Oleate (A3-129), were satisfactory as were flights of balloons made from compound A3-137 which contains Mistron Vapor. TASK B - EFFECT OF FLIGHT CONDITIONS ON BALLOON FILM PERFORMANCE. Spectral characteristics of white, red and black balloon films were determined. A study of the effect of ultra-violet radiation at 2800 A° was begun. A theoretical study of the dimensions of fast-rising balloons was made, and a similar study of the characteristics of constant level balloon films was conducted. An analysis of the stress in sounding balloons was made and equipment was designed and constructed to photograph balloons at the moment of burst. TASK C - STUDY OF BALLOON CONFIGURATION. Flights were conducted with two-piece streamlined balloons made from high-modulus compounds. Satisfactory altitudes were obtained, and the rate of ascent of the day-flight balloons was reasonably good. The rate of ascent of the night-flight balloons was, however, slower than desirable. TASK D - FIELD EQUIPMENT FOR PRECONDITIONING. No progress during this period.	Meteorological Balloon Film Development Signal Corps Contract No. DA-36-039-SC-84925

AD ______________ Accession No. ______________	Unclassified
Kaysam Corporation of America, Paterson, N. J. Study of Physical and Chemical Characteristics of Balloons and Balloon Materials By Eric Nelson, Herman Newstein & John Kantor Sixth Quarterly Progress Report, Oct. 24, 1961 Pages, 68 - Tables, 17 - Figures, 6 Signal Corps Contract No. DA-36-039-SC-84925 Dept. of the Army Project No. 3D36-21-001-04 Unclassified Report	Meteorological Balloon Film Development Signal Corps Contract No. DA-36-039-SC-84925

Progress is reported on work accomplished in connection with the following tasks: TASK A - STUDY OF BALLOON FILMS AND THEIR EFFECT ON BALLOON FLIGHT PERFORMANCE. An evaluation of three new neoprene polymers was begun, and the study of the behavior of aged neoprene latex was continued. Increasing the quantity of two accelerators increased elongation at +20°C and -40°C. Mistron Vapor was shown to increase modulus and tensile without reducing elongation. The use of zinc resinate was investigated and discarded. Compounds containing a Merac/Accelerator 833 blend were satisfactory. The use of Dibutyl Sebacate only in dual-purpose compounds gave unsatisfactory low-temperature elongation and gels which are too soft to handle. High-modulus compounds containing Mistron Vapor are generally satisfactory. Flights conducted with balloons made from compounds containing Merac (A3-132, A3-135 and A3-136), and Butoxy Ethyl Oleate (A3-129), were satisfactory as were flights of balloons made from compound A3-137 which contains Mistron Vapor. TASK B - EFFECT OF FLIGHT CONDITIONS ON BALLOON FILM PERFORMANCE. Spectral characteristics of white, red and black balloon films were determined. A study of the effect of ultra-violet radiation at 2800 A° was begun. A theoretical study of the dimensions of fast-rising balloons was made, and a similar study of the characteristics of constant level balloon films was conducted. An analysis of the stress in sounding balloons was made and equipment was designed and constructed to photograph balloons at the moment of burst. TASK C - STUDY OF BALLOON CONFIGURATION. Flights were conducted with two-piece streamlined balloons made from high-modulus compounds. Satisfactory altitudes were obtained, and the rate of ascent of the day-flight balloons was reasonably good. The rate of ascent of the night-flight balloons was, however, slower than desirable. TASK D - FIELD EQUIPMENT FOR PRECONDITIONING. No progress during this period.

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